

INSTRUCTIONS



Electronic Services - Los Angeles



Beckman®

INSTRUMENTS INC.
BERKELEY DIVISION



INSTRUCTION MANUAL

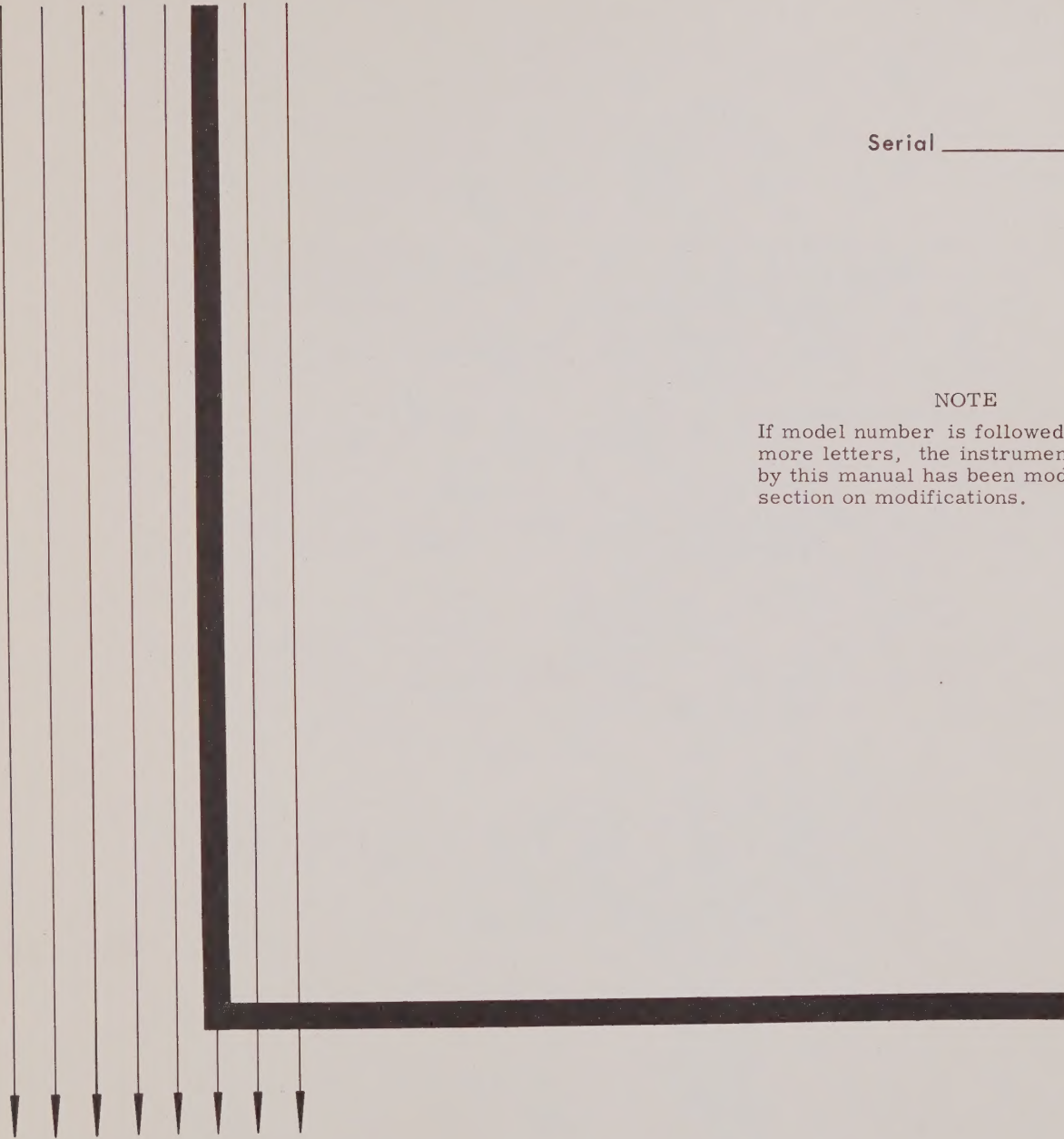
MODELS 7050 & 7060

ELECTRONIC COUNTERS

Serial _____

NOTE

If model number is followed by one or more letters, the instrument covered by this manual has been modified. See section on modifications.



Beckman®

INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

1959

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

- (a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in possession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.
- (b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.
- (c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.
- (d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.
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- (f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.
- (g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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BECKMAN/BERKELEY PARTS

IMPORTANT NOTE

We, at Beckman Instruments, Inc., have recently adopted a new nine-digit part numbering system which identifies each part utilized in our instruments. However, the parts lists of many of our instruction manuals are not yet updated for the new part numbering system.

Therefore, when ordering parts, please recognize that there may be a change in the part number.

If the parts list in your instruction manual does not conform to the new nine-digit system, it will be cross-referenced at the factory when you place your order.

Also, we have a continuing engineering program for improving and upgrading the performance of our instruments. So some of the parts that come in your equipment may have since been replaced by newer, better, more efficient and equivalent parts. Therefore, you might not always receive identical parts for replacement.

MANUAL REVISION

The instruments listed in Table 1 have been modified to increase their frequency range from 100 kc to 500 kc. Specifications for these instruments are:

Frequency range: DC to 500 kc

Resolution: 2 microseconds

TABLE 1

Model No.	Serial Numbers Affected
7050	322, 367, 422, 457, 459, 473, 478, 480, 482 and above
7150	1955 and above
7151	519 and above
7250	582, 583, 586 through 596, 599 and above
7350	1837 and above
7351	317, 336, 341, 343 and above
8050	108 and above
8150	131 and above
8151	135 and above
8250	104 and above
8350	120 and above
8351	113 and above

Instruments listed in Table 2 have been modified to increase their frequency range from 1 mc to 2 mc. Specifications for these instruments are:

Frequency range: DC to 2 mc

Resolution: 0.5 microsecond

TABLE 2

Model No.	Serial Numbers Affected
7060	752 and above
7160	1359 and above
7260	462 and above
7360	5276 and above
8060	110, 111, 114, 117 and above
8160	140 and above
8260	102 and above
8360	171 and above

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Model 7060 Master Schematic Diagram, Dwg. No. 63-D-15 (D413539-Rev. B)	
Power Supply, Schematic Diagram, (7370-C-PS)	
"A" or "B" Input Channel, Schematic Diagram, Dwg. No. C412829-Rev. C	
"C" Input Channel, Schematic Diagram, Dwg. No. C414497-Rev. A	
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Instruction Manual for Model 775, 775AJ & 775K DCU	
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GENERAL DESCRIPTION

Models 7050 & 7060 are electronic counters consisting of an electronic gate with controlling circuitry, a chain of decimal counting units and three input trigger channels. (See Figure 1). Voltage pulses applied to the gate will pass through to be counted by the decimal counting units during the period the gate is open. Other pulses applied to the gate controlling circuitry will open and close the gate. The DCU's register the number of pulses received and indicate this number by illuminated decimal digits on the front panel of the instrument. Counting accuracy is ± 1 count. The DCU's may be reset to zero automatically after a predetermined display period or the display may be retained until the operator resets the instrument manually.

Any of the three input trigger channels will generate pulses of suitable shape to be counted by the

DCU's or to actuate the gate controlling circuitry. Each channel produces one pulse for each voltage excursion through a preset trigger level at its input. Consequently, a cyclical input signal will produce one pulse for each cycle. There are three modes of operation differing in the method of gating. Under C/B-A operation, a pulse from one input channel opens the gate and pulses from a second channel are counted until a pulse from the third channel closes the gate. Under A/B operation, successive pulses from one channel open and close the gate and pulses from another channel are counted. Under COUNT operation, pulses from one input channel are counted and gating is accomplished by manipulating a front-panel switch.

The three modes of operation adapt the instrument to a surprising variety of applications, a few of which are considered on the following page.

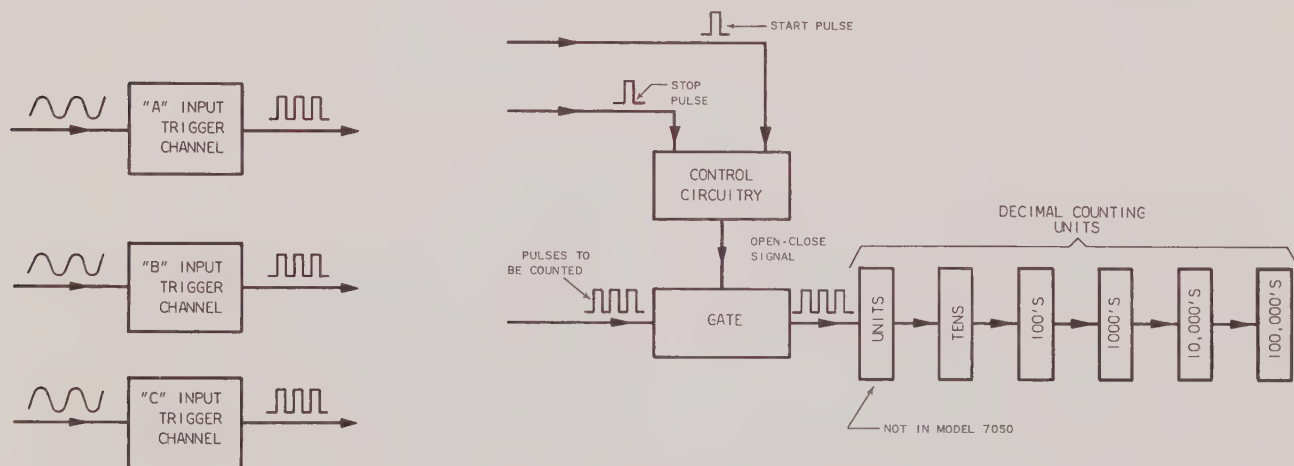


FIGURE 1. MAJOR COMPONENTS OF THE COUNTER.

DIFFERENCES BETWEEN MODELS

Model 7060 contains five 100Kcs DCU's and one 1Mcs DCU. Consequently, it has a maximum counting rate of 1Mcs and a registered count capacity of 1,000,000 counts. The Model 7050 is the same as the Model 7060 except that the 1Mcs DCU has been removed. This lowers its maximum

counting rate to 100Kcs and its registered count capacity to 100,000. Either model may be modified. If so, the model number will be followed by one or more letters. For information on modifications, see the section titled "Modifications".

SPECIFICATIONS

Gate, Control Circuitry and DCU's

Pulse Resolution

Model 7050: 5 microseconds
Model 7060: 0.8 microseconds

Count Capacity

Model 7050: 100,000 counts
Model 7060: 1,000,000 counts

Counting Accuracy

± 1 count

Display

In decimal digits. Display time continuously variable from 0.1 to 10 seconds.

Readout Facilities

Binary-coded decimal readout available at external connector

A & B Input Trigger Channels

Input Frequency Range
d-c to 1Mc/s

Input Impedance
10 megohms in parallel with 40 μ f

Input Sensitivity
100mv rms, 0.3 volts peak-to-peak

Input Voltage Attenuation
By factors of 1, 10 and 100

Input Coupling
A-C or D-C

Overload Limits

Input impedance drops below 10 megohms when instantaneous value of input voltage rises above +1 volt d-c after attenuation. Impedance is 1 megohm at +10v d-c.

Trigger Voltage Level

Continuously variable from -1 to +1 volt at the attenuated signal

Trigger Slope

Positive-going or negative-going

C Input Trigger Channel

Input Frequency Range
d-c to 1Mc/s

Input Impedance
1 megohm

Input Sensitivity
100mv rms, 0.3 volts peak-to-peak

Input Coupling
A-C or D-C

Trigger Voltage Level
Continuously adjustable from -1 to +1 volt

Trigger Slope
Negative-going

Overall Power Requirements

117 volts $\pm 10\%$, 50 to 60 cps, 225 watts.

APPLICATIONS

Frequency Ratio Meter. The counter will display in direct decimal form the ratio of two frequencies applied to separate input connectors: Useful for speed ratio measurements, oscillator frequency comparisons, etc.

Slave EPUT[®] Meter. Time base signals from another BERKELEY 7000 Series EPUT (Events-Per-Unit-Time) Meter or Universal EPUT and Timer can be applied to one input channel while the frequency to be measured is applied to the other channel. One or more Model 7050 or 7060 Electronic Counters can thus be connected in tandem to serve as slave EPUT meters.

Nuclear Counter. As manually or electronically gated counters, the Model 7050 and 7060 are useful in nuclear counting applications, especially where operation with digital printers or inline readouts is required. Paired pulse resolution of the Model 7050 is 5 microseconds; that of the Model 7060, 0.8 microseconds.

Digital Flow Computer. The sensitivity of an input channel may be increased to 5 millivolts at 5 cps by adding a pre-amplifier (designated Modification K). With this added sensitivity, the channel will accept the output of common digital flow transducers and the instrument may be used as a rate-of-flow meter if gated by timing pulses applied to another input channel. The instrument will also function as a flow totalizer either manually or electronically gated. For example, a burette valve may be rigged with a switch to deliver a gating signal so that the counter will indicate the total flow during the period the valve is open.

Slave Time Interval Meter. A time interval meter counts the number of time signals that occur between separate start and stop events. By connecting a source of standard timing signals to the Model 7050 or 7060, a time interval meter can be formed. The time signal frequency may be as high as 100Kcs in the case of Model 7050 and 1Mc/s in

the case of Model 7060. If Berkeley 7000 Series EPUT Meters, Time Interval Meters or Universal EPUT and Timers are used to furnish the timing signals, one or more Models 7050 or 7060 Electronic Counters may be operated in tandem as slave time interval meters. Timing signals at 1 microsecond intervals or decade multiples can be selected. The accuracy of measurement depends only on the accuracy of the timing signal source.

Digital Phase Meter. Digital phase measurements are a special application of time interval meters where the time interval is measured between like points of two electrical signals which differ only in phase. The "zero crossover" voltage of the two signals are usually selected as the reference points for greatest measurement accuracy. The measured interval is then related to degrees of phase shift.

Using a 100 KC timing source, the Model 7050 can make phase measurements with accuracies to 1 degree at frequencies to 278 cps. The 7060 will measure to 1 degree at frequencies to 2778 cps. By using a timing source of 144Kcs, the 7060 will measure directly in degrees with phase signals of 400 cps. Similarly, when the Model 7060 is equipped

with Modification J and a timing source of 1.44Mcs is used, measurement accuracy of 0.1 degree can be achieved with phase signals of 400 cps. More detailed information on this technique is given in BERKELEY Data File 107, "Precision Phase Measurements."

These are but a few of the many interesting and unique applications of these versatile instruments. Our engineers are eager to work with you in finding new applications. Your inquiries will receive prompt and thorough attention. Several Data Files describing typical applications have been prepared and copies may be had free of charge through any BERKELEY representative or from the factory.

Data File 101 - Electronic Timing
Data File 102 - Frequency Measurement
Data File 103 - Flow Measurement
Data File 104 - Electronic Control of Shearing
Data File 105 - Electronic Tachometry
Data File 106 - Velocity Measurement
Data File 107 - Precision Phase Measurement
Data File 108 - Pressure Measurement

ACCESSORIES

The versatility of the instrument can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 442 Reflecting Tachometer as well as several data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

The Model 5926 In-line Indicator presents a counter reading in large, bright red digits on a single horizontal line. The digits are about 1-1/4" high and lie in the same vertical plane; consequently, the indicator may be easily read from across the room and at nearly any angle to the face of the indicator. The Model 5926 receives count information from a 40-pin socket at the rear of the standard counter and need only be plugged into this socket and connected to a line power source to operate. The in-line indicator may be placed conveniently on top of the counter or both may be mounted in a standard 19-inch relay rack.

Beckman/Berkeley Data Reduction Converters, convert digital information from the counter

to a form suitable for actuating an IBM summary punch or an electric typewriter. These converters have uses similar to those of the Digital Recorder. Berkeley Digital to Analog Converters convert the count accumulated during each counting period to a representative voltage level. This voltage is held until a new count is completed when it changes to conform with the new count. The unit may be used

with a self-balancing potentiometer to provide an analog record, or the changing voltage level may be used to control the operation being monitored.

All accessory units described are available as standard models. In addition, special or modified versions can be ordered for specific applications.

INSTALLATION

The instrument is ready for use as it arrives from the factory. For proper cooling, it must be operated inside the cabinet. The unit can be taken out of its cabinet, and mounted in a standard 19 inch rack if a dust cover (available on order) is first installed over the top of the chassis. For chassis

dimensions see MODIFICATION R in section on modifications.

To energize the instrument, connect the power cord to a 117 v. AC source and turn the POWER switch on. After a short warmup period, the instrument will be ready for use.



FIGURE 2. FRONT VIEW OF MODEL 7060

OPERATING CONTROLS, CONNECTORS AND INDICATORS

POWER Switch (front panel)

Place in UP position to apply power to instrument. Indicator above switch lights when unit is energized.

FUNCTION Switch (front panel)

Determines method of gating pulses to decimal counting units. At A/B position pulses formed by A input trigger channel are counted between successive "start counting" and "stop counting" pulses generated by B input channel. At C/B-A position pulses formed by C input channel are counted between a "start" pulse from the B channel and a "stop" pulse from the A channel. Pulses generated by the B channel may be gated by moving switch from OFF to COUNT to start counting and back to OFF to stop counting. (See "Modes of Operation").

DISPLAY Control (front panel)

Determines how long the instrument displays a count indication before resetting to zero automatically and beginning another counting period. If this control is turned clockwise until a switch clicks audibly, the instrument will hold a reading until the manual RESET button is depressed. The DISPLAY control is inoperative at the OFF and COUNT positions of the FUNCTION switch. (See "Modes of Operation")

Manual RESET Button (front panel)

Depressing this button will reset the counter to a registered count of zero. (See "Modes of Operation").

"A" & "B" INPUT Jacks (front panel)

Input connectors for A and B input trigger channels. (See "Input Channel Adjustments").

"A" & "B" ATTENUATION Controls (front panel)

Attenuates the signal at the adjacent input jack by the voltage factor indicated by the pointer.

When turned to the AC side only the a-c component of the input signal reaches the input trigger channel. (See "Input Channel Adjustments").

"A" & "B" TRIGGER VOLTAGE Controls (front panel)

Selects the instantaneous voltage at which the attenuated signal triggers the A or B input channel. (See "Input Channel Adjustments").

"A" & "B" SLOPE Switches (front panel)

Selects the slope of the input waveform which triggers pulses used to actuate succeeding circuitry. At "-" the negative-going portion of the waveform triggers pulses. At "+" triggering occurs on the positive-going portion. At the A/B position of the FUNCTION switch, the SLOPE switch under the A-STOP bracket selects the slope of the B input waveform which triggers "stop counting" pulses. (See "Input Channel Adjustments").

AC INPUT Jack (rear of instrument)

Capacitively-coupled input to C trigger channel. (See "Input Channel Adjustments").

DC INPUT Jack (rear of instrument)

Direct-coupled input to C trigger channel. (See "Input Channel Adjustments").

"C" TRIGGER VOLTAGE Control (under cabinet lid)

Selects the instantaneous input voltage at which the "C" channel triggers. (See "Input Channel Adjustments").

DIGITAL RECORDER Jack (rear of instrument)

Each DCU generates a 4-line code representing the digit it is displaying. These lines are collected at the DIGITAL RECORDER socket at the rear of the instrument. Various Beckman auxiliary units, such as printers and in-line read-outs, plug directly into this socket. The socket also makes mutual control connections between the counter and the auxiliary device.

In the four-line code "0" represents a voltage 15 or more volts negative with respect to ground; "1" a voltage at ground or positive with respect to ground.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1
No Digit	0	0	1	0

	PIN NO. ON DIGITAL RECORDER SOCKET			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
Highest order digit read*	Pin 4	Pin 3	Pin 2	Pin 1
2nd highest order digit	8	7	6	5
3rd highest order digit	12	11	10	9
4th highest order digit	16	15	14	13
5th highest order digit	20	19	18	17
6th highest order digit**	24	23	22	21

* On instruments featuring "times ten" positions of the FUNCTION switch no read-out pins are provided for the left-most DCU, which displays the highest order digit during some measurements. On these instruments the highest order digit represented by a 4-line code is in the front-panel column second from left.

** On instruments containing only five read-out DCU's pins 21 thru 24 are permanently wired to produce the "no digit" code which is "0010".

Pin 39 carries a control signal from the counter. Under C/B-A or A/B operation, this pin is negative during the display period and positive from reset until the end of the next counting period. Under COUNT operation, the pin is negative when the FUNCTION switch is at OFF and at ground potential with the switch at COUNT.

Source impedance at pin 39 is nominally 250 K shunted by 100 μ f.

Pin 40 is the "inhibit reset" line. When this pin is grounded, the counter cannot reset.

Pins 26, 30 (7050 only), 31, 32 and 38 are grounded. Pins 25, 27, and 28 are connected to the -35 volt supply. Pin 29 and pins 33 through 37 are not used.

SCOPE Jack (rear of instrument)

This jack is connected through 220K to the suppressor grid circuit of the gate tube. The voltage at the jack is about -10 volts with respect to ground when the gate is open and about -40 volts when the gate is closed. If the waveform of a signal which generates start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack (after suitable conversion) may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the waveform whose duration is being measured.

GENERAL OPERATING PROCEDURE

Operation may be divided into three steps:

First: Selecting the proper mode of operation to accomplish a given object. There are three modes of operation corresponding to three positions of the FUNCTION switch: COUNT, C/B-A and A/B. The three modes differ primarily in the source of pulses counted by the DCU's and the method of opening and closing the gate. Each method is described separately below.

Second: Coupling appropriate signals to the input channels to be used and adjusting these channels so they produce desired output pulses. Input requirements and adjustments are described under "Input Channel Adjustments".

Third: Following the operating procedure for the selected mode of operation.

COUNT OPERATION

Under this type of operation, gating is manually controlled and the instrument counts pulses from the B input channel. This is a convenient method for counting input signals (such as random pulses from a nuclear detector) over an extended period of time. The major components are connected as shown in Figure 3. To take a count, proceed as follows:

1. Couple the input signal to the B INPUT jack and adjust the B input trigger channel. (See "Input Channel Adjustments").
2. Turn the FUNCTION switch to OFF. This disconnects the output of the B channel from the electronic gate.
3. Depress the RESET button. This resets the instrument to a registered count of zero and prepares the gate to be opened.
4. Twist the FUNCTION switch to COUNT. This opens the electronic gate and couples pulses from the B channel to the gate. The DCU's will start counting.
5. Twist the FUNCTION switch to OFF. This stops counting by disconnecting the B input chan-

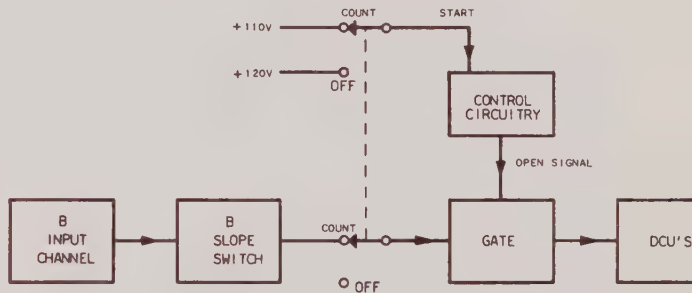


FIGURE 3. COUNT OPERATION

nel from the gate but does not close the gate. This action also supplies a signal to the Model 1452 Digital Recorder which causes it to print the accumulated count.

6. If you wish to resume counting without erasing the registered count, simply turn the FUNCTION switch back to COUNT.

7. Press the RESET button to return the instrument to a registered count of zero.

C/B-A OPERATION

With the FUNCTION switch at C/B-A, the major components are connected as shown in Figure 4. So connected, the instrument counts pulses generated by the C input channel during the interval separating a "start counting" pulse from the A channel. If the C input frequency is known, this operation may be used to measure the time interval separating the signals applied to the A and B input channels. When input signals A and B are out-of-phase signals of the same frequency, such a time measurement will reveal the phase difference. To operate, proceed as follows:

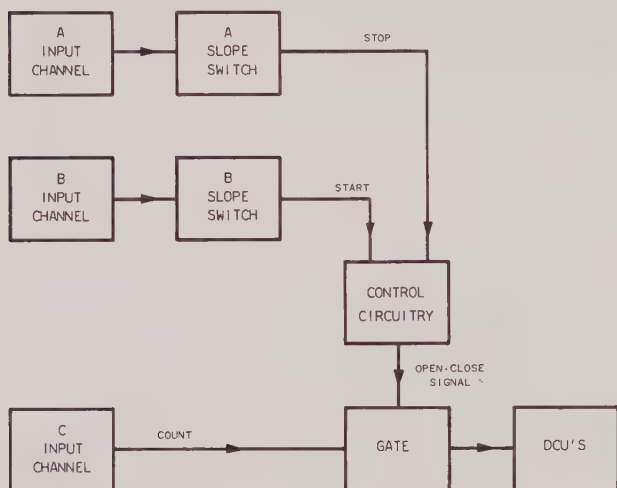


FIGURE 4. C/B-A OPERATION

1. Couple input signals to the A, B and C trigger channels and adjust the channel controls as described under "Input Channel Adjustments." Remember that adjustment of the A and B channels may be critical because the precise time at which "start" and "stop" pulses occur is important.
2. Rotate the FUNCTION switch to C/B-A.
3. Place the B slope switch at "+" if counting is to be started by a positive-going voltage excursion and at "-" if counting is to be started by a negative-going excursion. Position the A SLOPE switch similarly according to the polarity of the voltage excursion which should stop counting.

4. Press the RESET button to bring the instrument to a registered count of zero. Counting will start with a pulse from the B input channel and stop with a pulse from the A channel.
5. Position the DISPLAY control so that the count indication persists as long as desired after the counting stops. If the control is rotated until a switch clicks audibly, the instrument will not reset to a registered count of zero until the RESET button is depressed. If the Model 1452 Digital Recorder is attached, it will print the registered count after each "stop counting" pulse.

A/B OPERATION

With the FUNCTION switch at A/B, the major components are connected as shown in Figure 5. So connected, the instrument counts pulses generated by the A input channel during the interval between "start" and "stop" pulses from the B input channel. The result will be the ratio of the "A" input frequency to the "B" input frequency. If the "B" input signal consists of pulses separated by a precise time interval, the result of this operation is a count of events per unit time. Consequently, if the B INPUT is supplied with timing pulses from an EPUT meter, this counter will operate as a slave EPUT meter whose counting period is determined by the master instrument. On the other hand, if the A input consists of clock pulses, the instrument

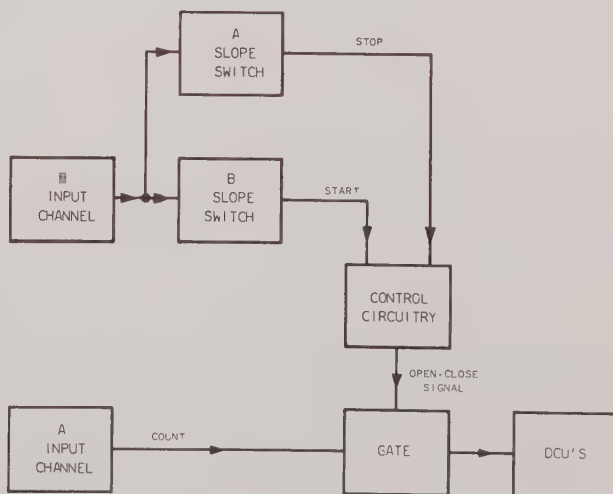


FIGURE 5. A/B OPERATION

will measure the time interval separating signals at the B input, thus making a period measurement. This setting of the FUNCTION switch may also be used to count the number of pulses from the A channel during the period the B input is above or below a certain d-c voltage level. To operate, proceed as follows:

1. Couple input signals to the A and B channels and adjust the channel controls as described under "Input Channel Adjustments". Unless the B input consists of sharp pulses such as would be obtained from a Berkeley EPUT meter, the adjustment of this channel may be critical because the precise time at which an output pulse occurs is important.
2. Place the FUNCTION switch at A/B.
3. Both SLOPE switches are now connected to the B input channel. The B SLOPE switch determines

the polarity of the voltage excursion which starts counting; the A SLOPE switch selects the polarity of the excursion which stops counting. When making an events-per-unit-time measurement using clock pulses from another 7000 Series EPUT meter, place both switches at "+". When making a period or frequency ratio measurement, place both at "+" or both at "-". When counting pulses from the A channel during the period the B input is above or below a certain voltage level, place one switch at "+" and the other at "-".

4. Press the RESET button to bring the instrument to a registered count of zero. Counting will start with the first pulse from the B input channel and stop upon the second pulse.

5. Follow step 5 under "C/B-A Operation."

INPUT CHANNEL ADJUSTMENTS

Routine Procedures

When to Use Routine Procedure. Under certain commonplace conditions it is possible to adjust the input channels successfully by following the routine procedures listed below. These conditions are:

- (a) Output pulses from channel are to be counted; will not be used to start or stop counting.
- (b) Input frequency is above 10 cps.
- (c) Input amplitude is roughly constant.
- (d) Input noise level is relatively low.

Whenever any of the above conditions do not hold, it is best to understand the way the input channels operate before attempting an adjustment. See "Effect of Input Channel Controls."

Routine Procedure for Adjusting "A" Channel.

1. Couple the signal to the A INPUT jack. Required amplitude is 0.3 volts peak-to-peak. Input impedance is 10 megohms in parallel with 35 micro-microfarads.
2. Open the gate by the following procedure. Place FUNCTION switch at A/B and place B SLOPE

switch at "+". With no signal at the B INPUT jack rotate B TRIGGER VOLTAGE control fully clockwise, then press RESET button and rotate the B TRIGGER VOLTAGE control fully counter-clockwise. At this point, the gate will be open.

3. Rotate the A TRIGGER VOLTAGE control slowly from one extreme to the other while the A ATTENUATION control is at each of the three positions on the AC side (1, 10 & 100). Notice that the instrument will count steadily over a certain arc of TRIGGER VOLTAGE positions for each ATTENUATION setting. Choose the highest ATTENUATION position (the most attenuation) at which counting will continue over an arc of at least 45° rotation of the TRIGGER VOLTAGE control. For example, if the instrument will not count steadily over an arc of 45° with the ATTENUATION control at "100", reduce attenuation to "10". If counting will still not persist over a 45° rotational arc, reduce attenuation to "1".

4. With the ATTENUATION setting selected, position the TRIGGER VOLTAGE control at the center of the arc over which counting occurs.

Routine Procedure for Adjusting B Channel.

1. Couple the signal to the B INPUT jack. Required amplitude is 0.3 volts peak-to-peak. Input impedance is 10 megohms in parallel with 35 microfarads.
2. Open the electronic gate by the following procedure. Place FUNCTION switch at OFF, press the RESET button, then move FUNCTION switch to COUNT.
3. Follow steps 3 and 4 under "Routine Procedure for Adjusting A Channel", substituting "B" controls for "A" controls.

Routine Procedure for Adjusting C Channel.

1. Couple the signal to the AC INPUT jack at the rear of the instrument. Required amplitude is 0.3 volts peak-to-peak. Input impedance is 1 megohm.

2. Open the electronic gate by the following procedure. Place FUNCTION switch at C/B-A and place B SLOPE switch at "+". With no signal at B INPUT jack, rotate the B TRIGGER VOLTAGE control fully clockwise, then press the RESET button and rotate B TRIGGER VOLTAGE control fully counter-clockwise. At this point, the gate will be open.

3. There is no attenuator in this channel. The TRIGGER VOLTAGE control is located on top of the chassis under the hinged lid on the cabinet. Rotate this control slowly from one extreme to the other, noting the points at which counting starts and stops. Then position the control in the center of the region in which counting occurs.

Effect Of Input Channel Controls

Figure 6 is a block diagram of an input channel. The A and B channels are just like that shown in the diagram. The C channel is the same except that it lacks the attenuator and slope switch and has two input jacks, one capacitively coupled to the difference amplifier and one direct-coupled. The C channel acts as though it contained a slope switch permanently positioned at "-".

The input impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. The input sensitivity is equal to 0.3 volts peak-to-peak times the factor to which the ATTENUATION control is set. The input grid begins to draw current when the input signal rises above +10v peak-to-ground after attenuation.

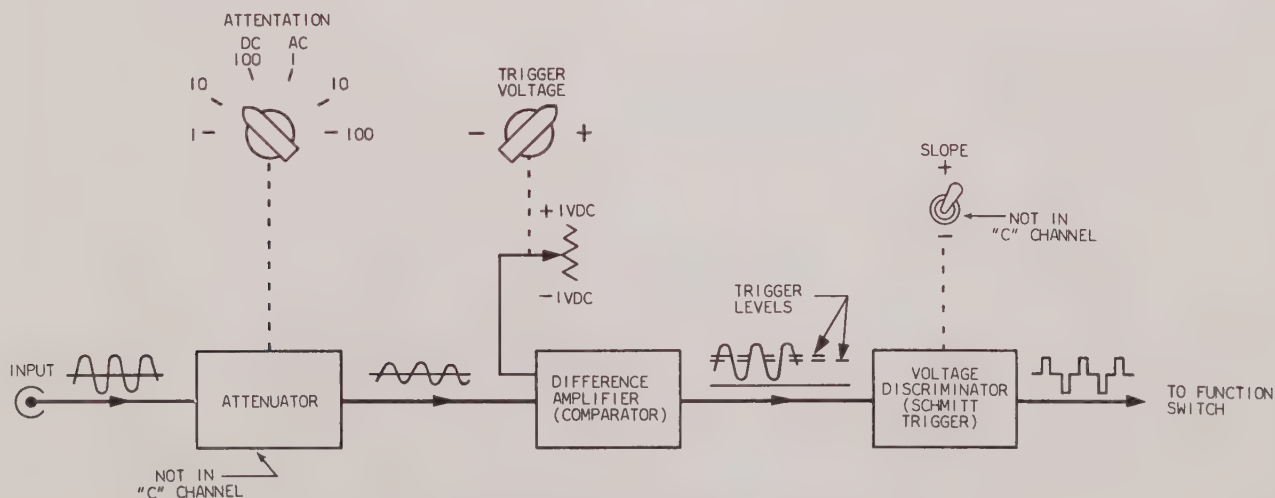


FIGURE 6. BLOCK DIAGRAM, INPUT TRIGGER CHANNEL

The attenuator divides the voltage introduced at the INPUT jack by the factor indicated by the ATTENUATION control. When the control points to a factor on the side labelled "DC", the total INPUT signal is attenuated and passed on the comparator. When the control points to a factor on the side labelled "AC", the d-c component is removed and only the a-c component is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" positions.

Figure 7 shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage". Another pulse is produced each time the instantaneous attenuated voltage passes through the "negative-going trigger voltage" starting from a value more positive than the "positive-going trigger voltage". When the SLOPE switch is at "+", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "-", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and negative-going) are always separated by 0.3 volts, the effective hysteresis. Because a voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.3 volts peak-to-peak. Both trigger voltage levels may be raised or lowered (maintaining 0.3-volt separation) by varying the TRIGGER VOLTAGE control. This control will vary the levels from roughly -1 volt to +1 volt. Referring to Figure 6, notice that the TRIGGER VOLTAGE control actually raises or lowers the d-c level of the input to the voltage discriminator. However, this action has the effect of lowering or raising the trigger voltage levels at the input to the difference amplifier.

The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTENUATION and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, a-c amplitude and d-c level. The effect of various control settings is then relatively easy to calculate. Referring to Figure 7, notice that:

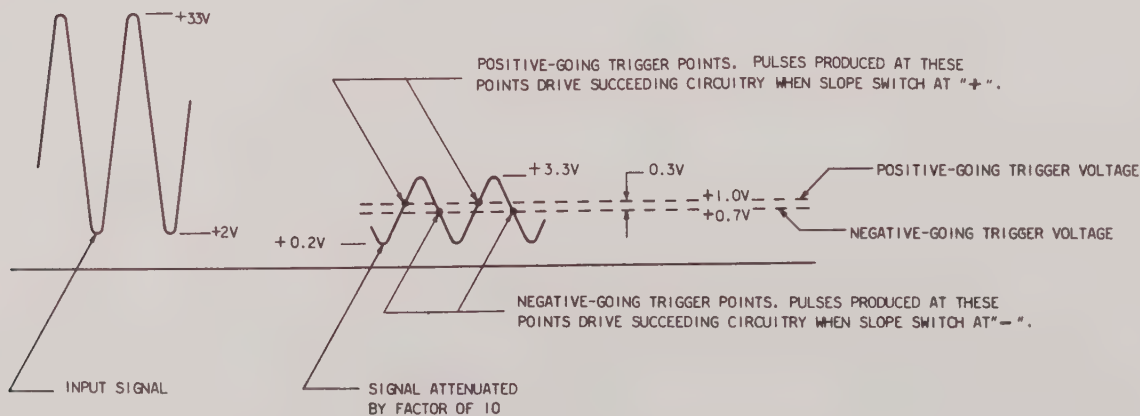


FIGURE 7.

1. If the attenuated signal is small peak-to-peak, the trigger voltage levels may be set so far positive or so far negative that no pulses are produced. In Figure 7, for example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -0.8 volts) the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.

2. If the attenuated voltage variations ride on a d-c level, they may not come within the trigger voltage range. In Figure 7, again, if the input signal were not attenuated (or a-c coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.

3. Modulation or variations in the d-c level of the attenuated signal are least likely to interfere with proper triggering if the trigger voltages are set about halfway between the peaks of the signal.

4. Noise below 0.3 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on a 6 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.6 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.

5. Attenuating the input signal

(a) Shifts the a-c component nearer ground if it rides on a d-c level.

(b) Increases the minimum peak-to-peak variations necessary to trigger pulses from 0.3 volts to 3 or 30 volts.

(c) Increases the range of possible trigger voltage setting on the input signal from ± 1 volt to ± 10 volts or ± 100 volts.

Adjustment of ATTENUATION and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any input signal of constant frequency, consistent readings for the same gate time are a good indication that the controls are properly adjusted.

The point on an input waveform where the input channel triggers is visible when the waveform is displayed on an oscilloscope. Observe the input of the voltage discriminator (V303, pin 2). The waveform which appears is the amplified input signal together with the small "notches" created on each slope as the channel triggers. Rotating the TRIGGER VOLTAGE control will cause these notches to move up and down the waveform.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltages may be varied between the positive and negative peaks of an attenuated signal whose peaks lie within the range -1 to +1 volt. As the trigger voltages pass beyond the signal peaks, the pulse output of the channel will cease and these positions of the control may be noted.

Principles of Operation

OVERALL DESIGN

(Refer to Block Diagram, Figure 8)

Any of the three input trigger channels will generate pulses of suitable shape to be counted by the DCU's or to actuate the gate controlling circuitry. Each channel produces one pulse for each voltage excursion through a preset trigger level at its input. Consequently, a cyclical input signal will produce one pulse for each cycle. The position of the FUNCTION switch determines which channel output will be coupled to the gate to provide pulses to be counted and which channel outputs (if any) will be coupled to the control circuitry to start and stop counting. The count section of the FUNCTION switch selects the source of pulses to be counted, the start section selects the source of the pulse which starts counting and the stop section selects the source of the pulse which stops counting.

At the OFF and COUNT positions of the FUNCTION switch, the start and stop sections are not connected to input channels. In this case, a start pulse is supplied by moving the switch from OFF to COUNT thus creating a negative transient at the wiper of the start section. While the switch is at COUNT, no stop pulse whatever will reach the control circuitry; counting is halted by moving the switch back to OFF, thus disconnecting the source of pulses to be counted.

Upon receiving a start pulse, the control circuitry opens the gate. When a stop pulse occurs, this circuitry closes the gate and sends a signal to the digital recorder (if one is attached) commanding it to scan the readout code and print the registered

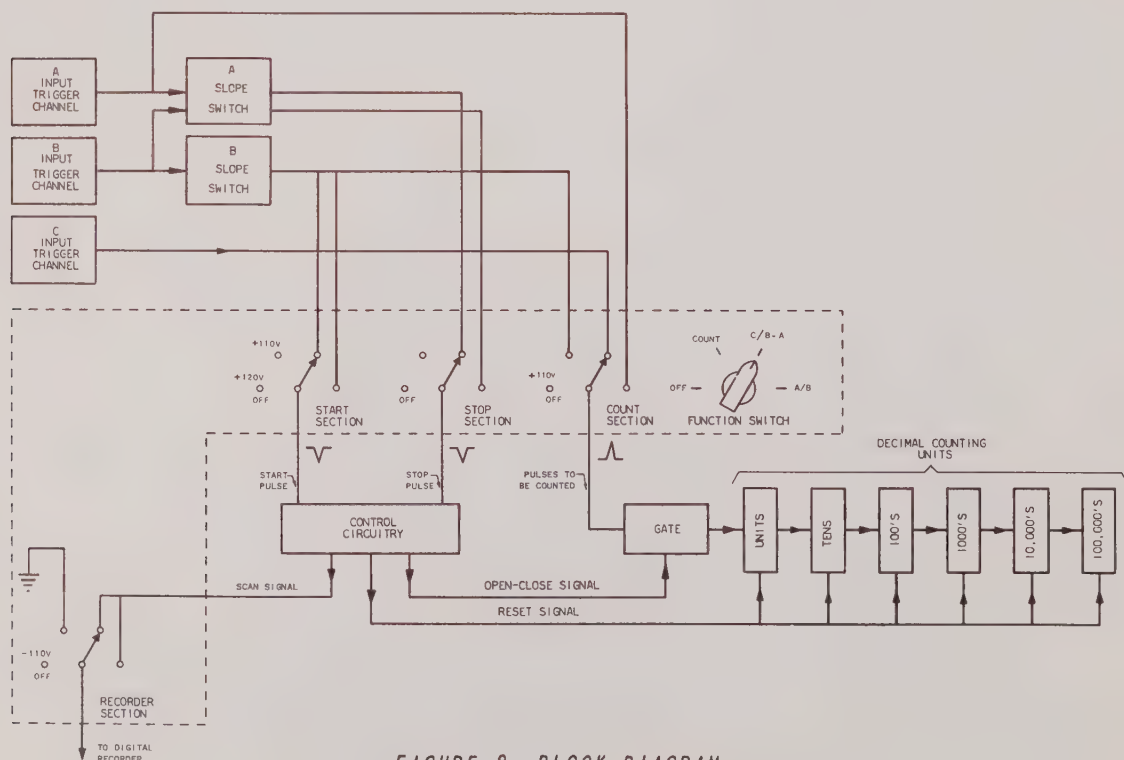


FIGURE 8. BLOCK DIAGRAM

count. The stop pulse also initiates a timing action in the control circuitry, and, at the end of a period set by the DISPLAY time control, the control circuitry generates a pulse which resets all DCU's to zero. Since no stop pulse occurs when gating is

manually controlled, the signal to the recorder is supplied by connecting the wiper of the recorder section of the FUNCTION switch to -110 VDC and the reset signal is generated by pressing the manual RESET button.

INPUT TRIGGER CHANNELS

(Refer to Schematic Diagram)

All three input trigger channels are identical except that the A and B channels have input attenuators and a switch actuated by the ATTENUATION control for selecting a-c or d-c coupling. The C channel has no attenuator and is provided with separate input jacks for a-c and d-c coupling. The attenuator divides the input voltage by 1, 10 or 100 according to the position of the ATTENUATION control. When the ATTENUATION control is at an AC position, a .01 μ f capacitor (C301) is inserted in series between the INPUT jack and the attenuator.

The comparator amplifier has two stages. The first is a difference amplifier whose output is proportional to the input voltage on the grid of V301A minus a selected constant voltage on the grid of V301B. The TRIGGER VOLTAGE potentiometer (R318) varies the voltage on the grid of V301B between -1 and +1 volts. The second stage (V302) amplifies the double-ended signal received from V301 and converts it to a single-ended low impedance output at the left-hand plate. This plate is connected to the input grid of the discriminator.

The voltage discriminator (V303) produces an output pulse each time the input voltage on its left-hand grid passes through a fixed voltage level (about +60 volts). Consider the input to this circuit as an a-c triggering signal superimposed on d-c level. The a-c signal is an amplified reproduction of the voltage variations on the grid of V301A, that is, the attenuated input. The d-c level is determined by the voltage on the grid of V301B, a voltage set by the TRIGGER VOLTAGE potentiometer. As the TRIGGER VOLTAGE pot is rotated toward "+", the d-c level is lowered and the discriminator triggers at a higher instantaneous voltage of the a-c signal and at a higher attenuated input voltage to the channel. When the TRIGGER

VOLTAGE control is turned toward "-", the channel triggers at a lower attenuated input voltage.

The discriminator (V303) is a two-stage positive feedback amplifier. Feedback from the output stage occurs through the cathode coupling. The loop gain is slightly greater than one so that the circuit is regenerative and tends to assume one of two stable states. The output stage draws a steady current as long as the input grid remains below a certain triggering voltage. When the input exceeds this voltage, the output tube is suddenly cut off. When the input voltage returns to a value slightly below the initial triggering voltage, the output stage builds rapidly to its original steady current.

The difference between the level at which a positive-going voltage change triggers the circuit and the lower level at which a negative-going voltage change re-triggers it is called the hysteresis of the circuit. At the input to the comparator amplifier, the hysteresis is about 0.3 volts. The hysteresis determines the input sensitivity. An attenuated input signal weaker than 0.3 volts peak-to-peak or about 0.1 volts rms will not trigger a series of pulses. This means that any noise at the attenuated input below this level will not trigger extraneous pulses, although it may affect the time at which a pulse occurs.

The primary winding of T301 differentiates the rapid current changes in the output stage to produce a positive pulse at the plate when the circuit is triggered by a positive-going voltage and a negative pulse when triggered by a negative-going voltage. The secondary of T301 produces inverted pulses -- a negative pulse when the circuit is triggered on a positive slope and a positive pulse when triggered on a negative slope.

GATE & CONTROL CIRCUITRY

(Refer to Master Schematic Diagram)

The gate and control circuitry receive three pulse inputs from the FUNCTION switch (S201): pulses to be counted, start pulses and stop pulses. Pulses to be counted go from the count section to the signal grid of the Gate tube (V204). The plate of this tube is coupled to the first of the cascaded DCU's. During the period its suppressor grid is at ground, the tube amplifies the grid signal and drives the DCU's. In this state, the Gate is "open". When the suppressor grid is below -10 volts, the tube is cut off and the Gate may be considered "closed".

NOTE: The terms "right" and "left" refer to directions on the schematic diagram.

The "open-close" voltages on the Gate tube suppressor grid are generated at the right plate of the Control Binary (V203). V203 is a conventional "flip-flop" circuit. Such a circuit has two stable states: left half conducting, right half cut off and right half conducting, left half cut off. Input pulses or transients applied at various points on the circuit will trigger it back and forth between the two states. When the right half of V203 is conducting, the right plate is 30 volts negative. A negative start transient from the Start Binary, applied at the left plate of V203 and coupled through C210 to the right grid, triggers V203 to its other stable state. In this state the right half is cut off and the right plate rises above ground permitting the Gate tube to conduct. When a negative stop pulse from the stop section of the FUNCTION switch reaches the left grid of V203 through the diode CR212 V203 is triggered back to the state which holds the Gate closed.

The Start Binary is also a "flip-flop" circuit. It produces a negative start transient at its right plate each time that half begins to conduct. Its left grid is coupled to the start section of the FUNCTION switch through the diode CR211 and C201. When the left half is conducting, a negative start pulse at the grid triggers a change to the other stable state producing the output transient. Further negative pulses at the left grid have no effect since that half is already cut off.

When the instrument is ready to begin a counting period, the right half of the Control Binary and the left half of the Start Binary are conducting and the Gate is closed. Negative stop pulses received at the left grid of the Control Binary have no effect since this half is cut off. The following sequence occurs. (Refer to Figures 9 and 10)

Time ① A start pulse passes through the injection diode CR211 and triggers the Start Binary which, in turn, triggers the Control Binary to a state which opens the Gate. The DCU's then count and indicate the number of pulses reaching the Gate.

Time ② A stop pulse triggers the Control Binary to a state which closes the Gate.

At this point, if the instrument is set to operate automatically, the reset circuitry begins to function. The reset control voltage appears at the junction of CR201 and CR203. Its value is determined by the combined effect of the voltage on the right plate of the Start Binary and that on the right plate of the Gate Control Binary. At the close of a counting period (and only then) both these plates are negative. The resulting negative voltage at the junction is applied to the input grid of the Reset Control through R237 and R239.

This negative voltage biases the left-hand section of the Reset Control tube (V205) to cut off, and the resultant rise in plate potential is coupled to the right-hand grid. Since the right-hand section of V205 operates as a cathode follower, the rise in potential at the grid produces a voltage rise at the cathode. This voltage rise, applied at the junction of resistor R248 and the DISPLAY potentiometer (R247), causes capacitor C216 to discharge through R247. As the capacitor discharges, the potential at the input grid (pin 7) of the Reset Generator (V206) rises.

The Reset Generator is a monostable multivibrator. In its stable state, the right-hand triode section is conducting while the left-hand section is cut off. When the potential on the left-hand grid becomes sufficiently positive, it triggers the Reset Generator to its quasi-stable state. (i.e., left side conducting, right side cut off). This occurs at time ③,

with the interval between time ② and time ③ depending on the setting of the DISPLAY control (R247).

At time ③ then, the potential at the left-hand plate of the Reset Generator drops, while that at the right-hand plate goes up. The drop in voltage at the left-hand plate, coupled through capacitors C214 and C215 to the DCU reset lines, produces a negative pulse which resets the DCU's. This same reset pulse also triggers the Start Binary to its initial (left side on) state and makes sure the Control Binary is triggered to its "right side on" state. The rise in voltage at the right-hand plate of the Reset Generator is fed back to the input grid of the Reset Control tube and triggers it to its original state. (i. e., left side on, right side off). This same voltage rise also puts a reverse bias on diode CR211 so that start pulses can not pass through to trigger the Start Binary.

The Reset Generator remains in its quasi-stable state for 15 milliseconds. At the end of that period, time ④, the Reset Generator jumps back to its stable state (right side on, left side off), and the voltage on the right-hand plate drops. This removes the reverse bias from diode CR211. The Reset Control, however, is not triggered at this time because when the Start Binary is reset, the potential on its right-hand plate goes up and the reset control line is clamped to this higher potential by diode CR201. Thus, the 15 millisecond delay provided by the Reset Generator keeps any start pulses

from triggering the Start Binary, to initiate counting, until all reset transients have decayed. The next start pulse triggers the Start Binary to its "right side on" state which, in turn, triggers the Control Binary to its "left side on" state. To prevent reset action at this time, diode CR203 clamps the reset control line to the relatively high positive potential at the right-hand plate of the Control Binary. The next stop pulse triggers the Control Binary to its "right side on" state, the potential at the right-hand plate drops, and the entire reset process is repeated.

NOTE: When the counter operates with a Berkeley Digital Recorder, the operating cycle is briefly delayed at the end of the counting period (time ②) until the recorder has received all of the count information from the DCU's (see Figure 11). This delay is produced by a relay in the recorder which grounds the input to the DISPLAY potentiometer (R247) through pin 40 of J202 for the required interval.

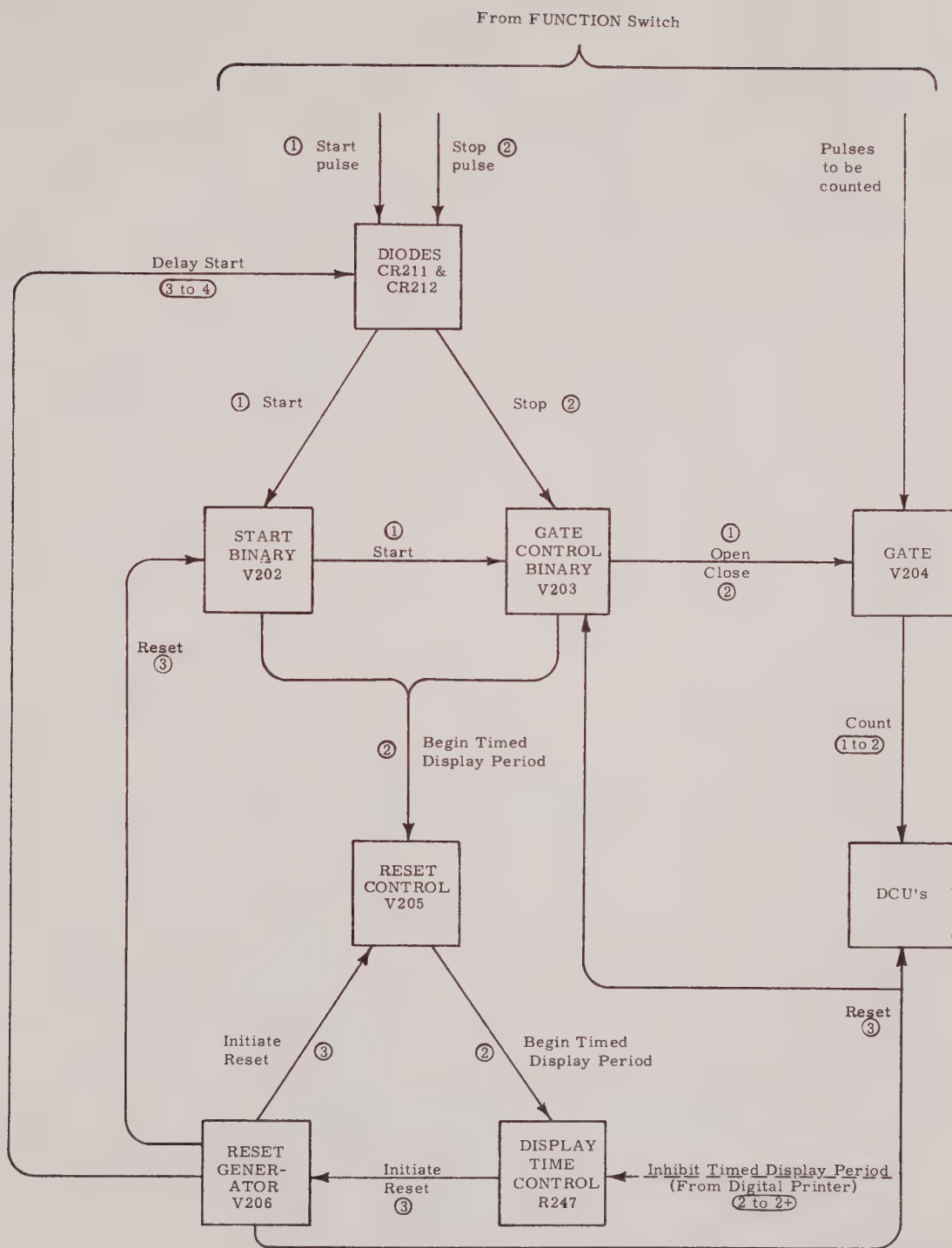
When the DISPLAY control is turned fully clockwise into its infinity position, the input connection to R247 is broken by switch S204 and automatic reset will not occur. Consequently, the DCU's will hold the registered count until the RESET button is pressed. When this is done, the contacts of switch S205 are shorted, and a positive pulse is applied to the left-hand grid of the Reset Generator. This positive pulse triggers the Reset Generator, and causes it to produce a reset signal just as in automatic operation.

POWER SUPPLY

Two bridge rectifiers supply +210 volts unregulated and -110 volts unregulated. From these voltages are derived +120 volts regulated, -60 volts regulated, and -35 volts unregulated.

A Zener diode (CR106) stabilizes the -60 volt supply. This in turn acts as a reference voltage for the +120 volt regulator circuit, which consists of an amplifier (V101) and a series regulator tube (V102). A voltage divider (R106, R107, R113, R116) is connected between the regulated +120 volt supply and the -60 volt reference. The control grid of V101 is connected

to a point on this divider that is adjusted by R113 (the +120 V ADJUST control) to be slightly below ground when the regulated output is +120 volts. Since the plate of V101 is coupled through R105 and R110 to the control grids of V102, any increase in the regulated output voltage appears as a decrease in the grid bias applied to V102. The plate resistance of V102 increases, and with it the voltage drop across the tube; so the output voltage drops back to +120 volts. Similarly, if the output voltage goes down, the plate resistance of V102 decreases, thus restoring the output to +120 volts.



NOTE: Circled numbers indicate time of operation as labeled on the Timing Diagrams.

FIGURE 10. FUNCTIONAL DIAGRAM OF GATE AND CONTROL CIRCUITRY.

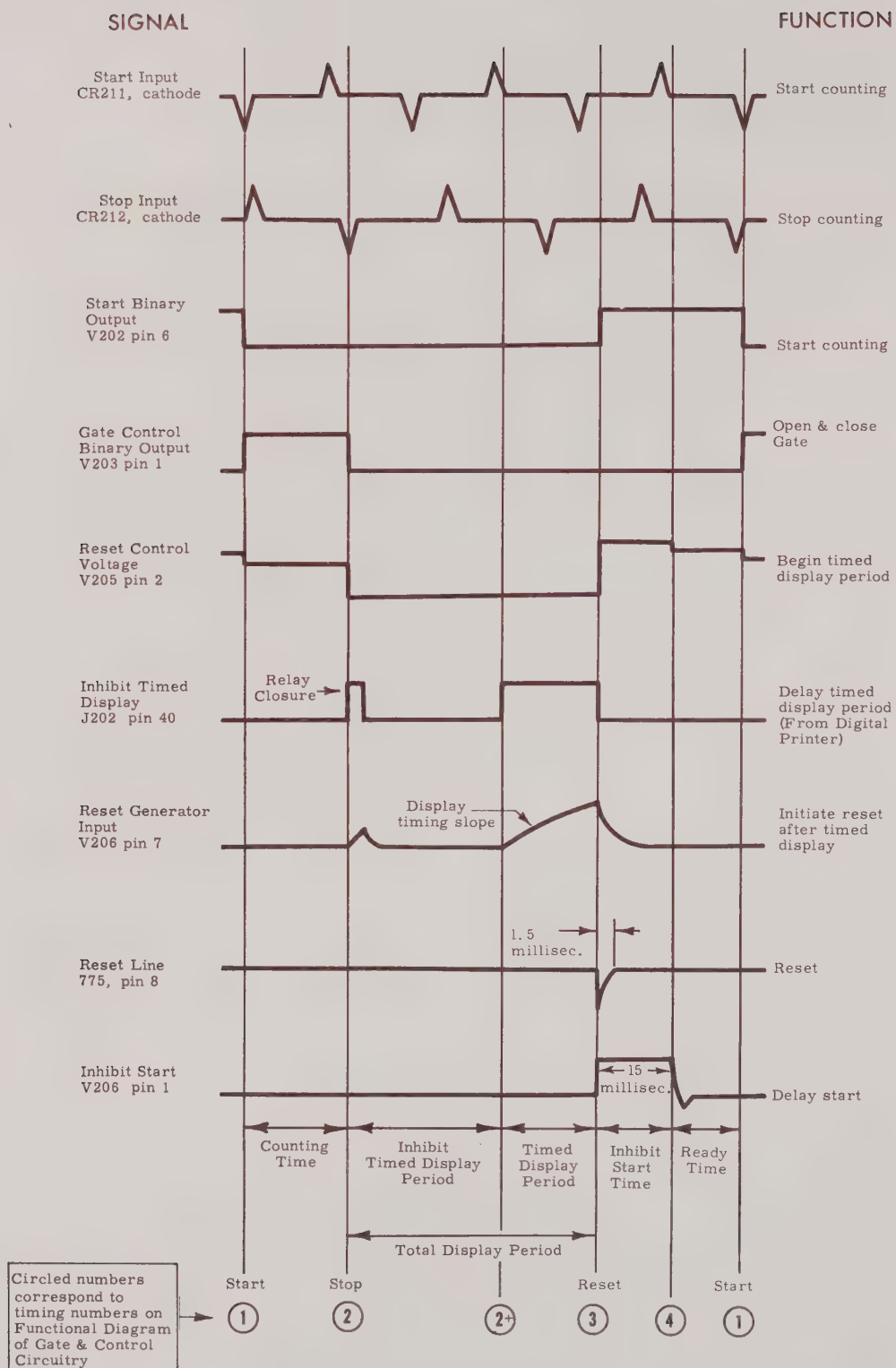


FIGURE 11. CONTROL CIRCUIT TIMING DIAGRAM WHEN COUNTER IS EQUIPPED WITH DIGITAL RECORDER.

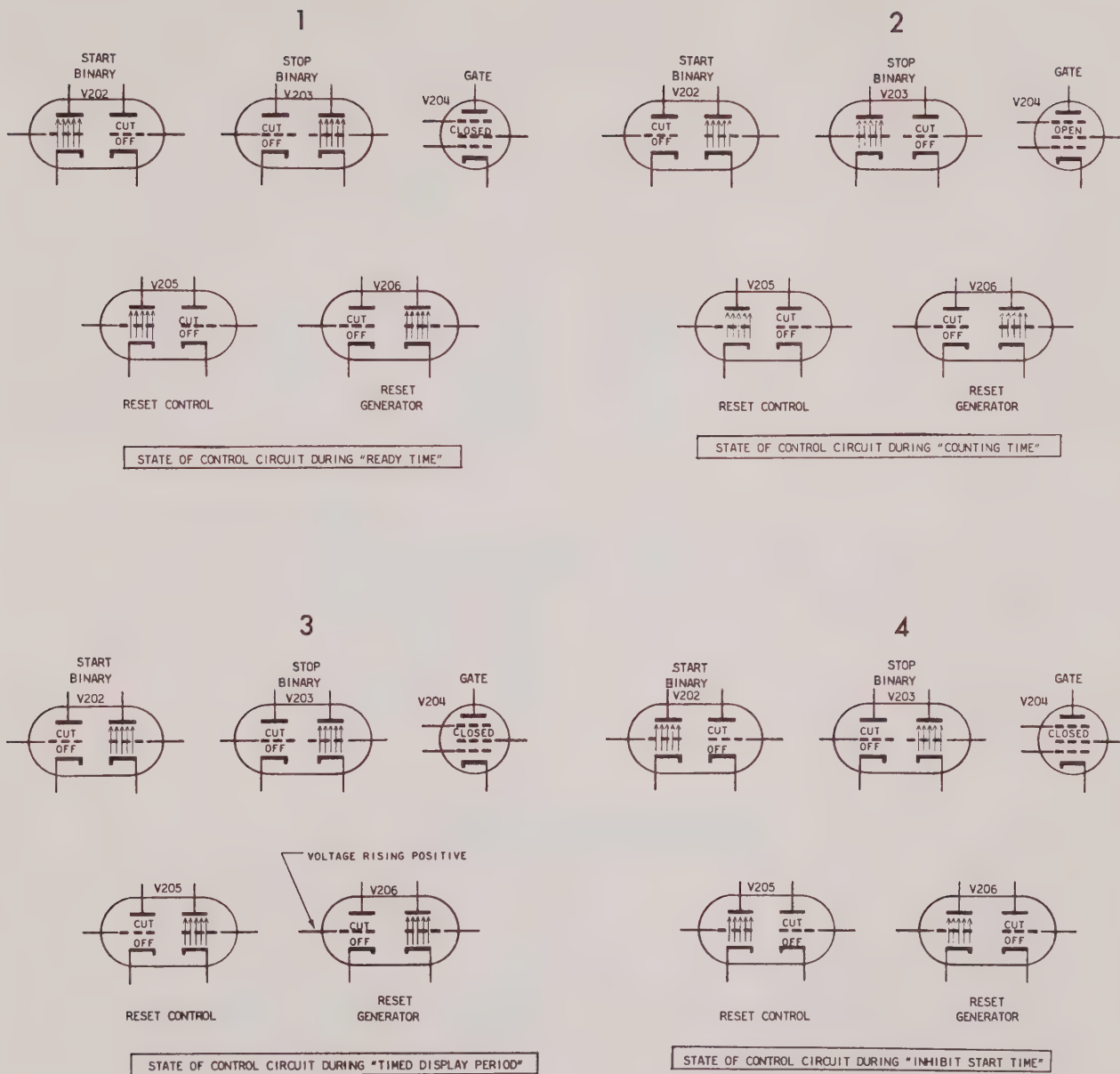


FIGURE 12. TUBE STATES DURING THE OPERATING CYCLE.

Servicing

ADJUSTMENTS

Regulated 120-Volt Supply

Use the +120 V ADJUST control on the rear panel to set the voltage at the +120 lug of the power supply terminal strip to +120 volts.

Attenuator

Two ceramic trimmer capacitors on each attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. When the counter chassis is upside down and the attenuator shafts are pointing at the viewer, the capacitor

on the right side of each attenuator is C303 and that on the left C302. To adjust, apply a 500 cps square wave signal at one of the counter INPUT jacks. Observe the corresponding amplifier output at Pin 1 of V302 with a 100 KC band-width oscilloscope. Turn the attenuator to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the attenuation control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

PREVENTIVE MAINTENANCE

Since a tube tester will not detect tubes which are likely to cause trouble and it is undesirable to replace tubes wholesale as they grow old, other methods must be used to forestall failures. The most effective method is "marginal checking". In its

simplest form this consists in causing intermittent or latent failures to manifest themselves by operating the instrument at exceptionally high or low line voltages. A variable auto-transformer may be used to manipulate the line voltage.

TROUBLESHOOTING

The following test equipment is necessary to service the instrument effectively:

1. An oscilloscope, sensitivity 1/4 volt, band-width 5 MC, preferably direct coupled.
2. A signal generator, frequency range 100 cps to 1 MC, output at least 100mv rms.
3. A vacuum tube voltmeter.

When the instrument fails to perform properly, first make sure that it is being operated correctly. Some common errors in operation are:

1. TRIGGER VOLTAGE control positioned incorrectly.
2. ATTENUation control set incorrectly.
 - (a) Wrong choice of AC or DC coupling.
 - (b) Attenuated signal too strong or too weak.
3. SLOPE switches set incorrectly. (See "PERFORMING SPECIFIC OPERATIONS" for correct

- setting for each operation.)
4. Input signal coupled to wrong jack.

When it is certain the instrument is functioning improperly, first check the power supply voltages to see that they are close to the following values:

	Limits of	Acceptable
<u>Supply</u>	<u>Average Level</u>	<u>Ripple, peak to peak</u>
Unreg. Pos.	+200 to +230 v	15 v
Unreg. Neg.	-100 to -120 v	12 v
Reg. Pos.	+120 v	0.1 v
Reg. Neg.	-54 to -66 v	0.4 v

When the trouble has been traced to one of the major components, consult the Circuit Description section of this manual and the pictured waveforms for guidance in locating the specific fault. The Input Trigger Channels may be conveniently checked by observing whether or not a pulse is produced as the TRIGGER VOLTAGE control is rotated from one extreme to the other and back.

Tubes, chokes, germanium diodes and pulse transformers are the most common sources of trouble. A transconductance tube tester will not always detect a faulty tube, and, conversely, the tester may reject a tube which is functioning properly. Although the circuits are designed for wide tube variation, avoid swapping tubes or wholesale replacement. An aged tube is generally more reliable than a new tube, because catastrophic failure usually occurs early in the life of a tube if at all. An aged tube undergoes only a gradual loss of transconductance, emission, etc.

If the supply voltages are adequate, the next step is to trace the failure to one of the major components. This can be done by observing the start, stop and count pulses at Decks C, E & G respectively of the FUNCTION switch. If the signals at these points approximate the proper output waveforms of the pulse sources, the trouble lies in the Gate and Control Circuitry or the indicating DCU's. Refer to the schematic diagram of the Gate and Control Circuitry to determine the source of pulses when the FUNCTION switch is in a particular position. If a deficient pulse is found, the trouble lies in that pulse source.

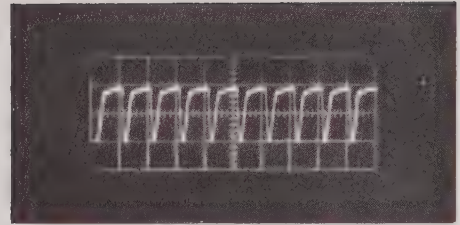
The Sylvania 6U8 tube is recommended for use in trigger circuit V303. (There are three V303 stages-- one in each input trigger channel.)



Start Binary output (V202, pin 6) with "Start" and "Stop" pulses separated by 10ms. (Upper level of waveform is at -11 volts.

Vert. scale: 20v./div.

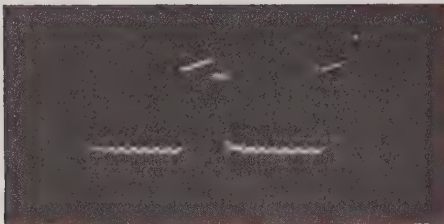
Horiz. scale: 20ms/div.



Signal Gate output (V204, pin 5); with 1 MC input signal.

Vert. scale: 5v./div.

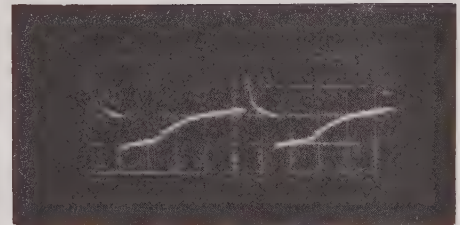
Horz. scale: 1 μ s/div.



Reset Control input (junction of R236 and R239) or print command (J202, pin 39); with "Start" and "Stop" pulses separated by 10ms., and minimum display time.

Vert. scale: 10v./div.

Horiz. scale: 20ms/div.

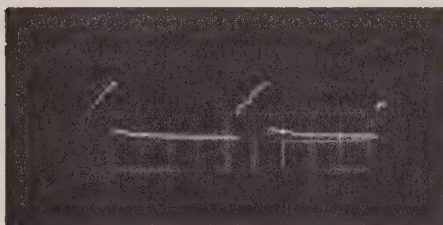


Reset Generator input (V206, pin 7); with "Start" and "Stop" pulses separated by 10ms., and minimum display time.

Vert. scale: 20v./div.

Horiz. scale: 20ms/div.

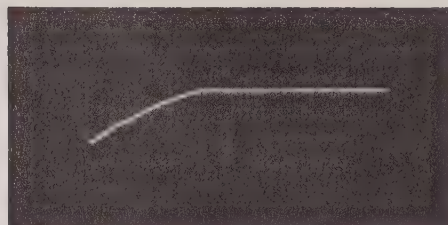
FIG. 13A TYPICAL WAVEFORMS



Reset Generator output (V206, pin 1);
with "Start" and "Stop" pulses separated
by 10ms., and minimum display time.

Vert. scale: 50v./div.

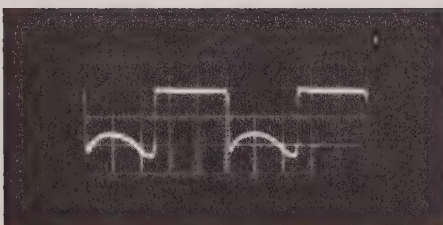
Horiz. scale: 20ms/div.



Reset pulse (junction of C215 and
CR205); 5 μ s rise time.

Vert. scale: 50v./div.

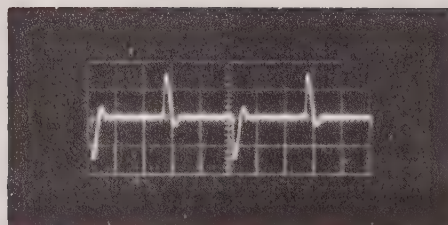
Horz. scale: 500 μ s/div.



Discriminator Amplifier plate (V303,
pin 6); with 100 KC input signal.

Vert. scale: 5v./div.

Horz. scale: 2 μ s/div.



Discriminator output (V303, pin 1); with
100 KC input signal.

Vert. scale: 5v./div.

Horz. scale: 2 μ s/div.

FIG. 13B TYPICAL WAVEFORMS

Supplementary Service Notes, SSN7000

Introduction. These notes cover recommended methods of servicing any instrument in the BECKMAN/Berkeley 7000 Series. This includes Models 7050, 7060, 7150, 7160, 7250, 7360, and the counter portion of Model 5571. Some of these instruments do not contain all the major components treated below (for example, Models 7250 and 7260 do not contain a frequency dividing chain); therefore, ignore inapplicable references.

Training and Experience Required. Any person who knows basic electronics and has used a scope and vacuum-tube voltmeter should not hesitate to undertake the repair of a Beckman counting instrument. Short of actual factory training, reading the instruction manual is the best way to familiarize oneself with the instrument. A detailed study of the schematics will yield additional knowledge, and, studied along with an actual instrument removed from the cabinet, will familiarize one with the layout of the components. Strive to keep the block diagram in mind, the details will fall in place as experience is gained.

Checking Instrument Upon Receipt. Occasionally, upon receipt by a customer, an instrument will fail

to operate properly. This may be due to rough handling or vibration that has taken place in shipment. The cause of the trouble most often will be a loose tube or perhaps some other loose plug-in component, such as a DCU or a crystal. In some cases a time base divider may require re-alignment, but rarely is more than one divider out of adjustment. Refer to the manual for proper alignment procedure, and be sure to use an auto-transformer on the 117-volt input line in order to test the alignment over any expected line swing within the specified variation of ± 10 per cent. Check to see that the switch on the cooling fan is turned on. At the same time make sure the INT-EXT switch on the oscillator sub-chassis is in the INT position. If the pilot light fails to come on when the POWER switch is thrown, there is probably a loose or broken line fuse. These fuses are located on the rear of the chassis.

Routine Care of Instrument. As time goes on, dust and grit may accumulate inside the chassis. This should be removed with an air hose and brush to prevent deterioration of components. Remove the tubes and clean the tops of the sockets with a rag. Make sure that the cooling fan rotates at normal speed.

HOW TO TRACE A FAULT TO A MAJOR COMPONENT

Examining Operating Characteristics. Refer to the schematic diagram of the gate and control circuitry. You will notice that the complete instrument, excluding the power supply, is shown on this page either in detailed schematic form or block diagram. It is your best overall look at the instrument and with reference to this diagram you can trace the signal and pulse paths through the function switch to their destinations. Understanding this diagram is the key to the isolation of troubles in the entire instrument. Notice that the input trigger channels, the oscillator and the frequency dividing chain all feed pulses to the FUNCTION switch, but that at some positions of

the FUNCTION switch not all the pulse sources are coupled to succeeding circuits. Since some major components are not used while performing certain operations, a fault may often be localized by observing which functions fail. For example, no pulses from an input trigger channel are used during the TEST operation; therefore, one may reasonably suppose an input channel is at fault if the instrument operates all right at TEST, but does not operate with an input signal. To take another example, the frequency dividing chain has no part in the COUNT operation, so if the instrument performs this function successfully when other functions fail, one may suspect the dividing chain.

Signal Substitution Using Another 7000 Series Instrument. Another 7000 Series instrument in good operating condition is a great help in localizing trouble. Make up a couple of patchcords, three or four feet in length, and having the BNC type connectors on both ends. These will serve to conduct pulses from one unit to another. On the rear lip of the chassis you will find two connectors, one labeled TIME and the other FREQ. The clock pulses from the frequency dividers are available at the TIME jack, and the oscillator frequency is present at the FREQ jack.

If you suspect incorrectly timed clock pulses in a faulty instrument, their accuracy can be checked by introducing the clock pulses from a good instrument into the B channel of the defective instrument and obtaining a readout in the PER function. Make this test with several combinations of the TIME-SECONDS switch on both instruments. Have both SLOPE switches at the same polarity. Be sure that the oscillator of the good instrument has been carefully set to the correct frequency before attempting this type of test.

Another test is to patch the oscillator output from the good unit into the FREQ jack of the faulty one and throw the INT-EXT switch, located on the oscillator sub-chassis, to the EXT position, thus by-

passing the oscillator of the defective instrument. Don't overlook the possibility of counting the clock pulses from a good instrument as a check on the accuracy of the E/UT function of a suspected instrument.

Observing Pulses at the FUNCTION Switch. The FUNCTION switch consists of four wafers. With one exception, there are contacts on both sides of each wafer. The contacts on each side make up one section, and each section is identified on the schematic diagram of the gate and control circuitry by a letter from A to G. Section A is the rear side of the wafer nearest the front panel (the forward side of this wafer is not used). The forward side of the second wafer is section B; the rear side, section C, and so on. A scope probe may be conveniently placed on the wiper contacts of sections C, E and G in order to observe "start", "stop" and "count" pulses respectively. These pulses originate in one or another of the major components depending upon the position of the FUNCTION switch. By rotating the switch to various positions, one may observe the output of an input channel, the oscillator-shaper, and (in conjunction with the TIME switch) the output of any frequency divider.

INPUT TRIGGER CHANNELS

Referring to the schematic, notice that the internal test signal does not pass through an input trigger channel, so, given a correct reading at TEST, it is a good bet that the trouble lies here. There are only three tubes in an input channel and the entire channel is contained on one sub-chassis. Thus troubleshooting is confined to a small amplifier-shaper section of the circuitry.

No one can state as a general rule where the trouble will be found in an input channel. The most likely cause of trouble is a defective tube and substitution should be tried. Then, of course, find out if the correct supply voltages are present. It is always wise to check supply voltages before doing any trouble-shooting, but remember if we found a correct TEST reading, we can assume that the supply

voltages are correct for most of the circuitry. Ordinary signal tracing, using the scope, may be employed on an input channel and typical voltages listed on the diagram may be verified with a vacuum-tube voltmeter. Don't overlook comparison of waveforms with those of a similar instrument that you may have in your possession, but remember that the attenuator and trigger voltage controls should be in

identical positions on both instruments. Turn off the power to the faulty instrument and take resistance measurements, perhaps the defective component will show up by this method. At any rate one of the above methods should yield results and the time required for the repair will depend on the skill of the technician and his familiarity with the instrument.

OSCILLATOR-SHAPER

The oscillator is the heartbeat of a 7000 series instrument; without it, operation ceases, except for the A/B function which is independent of the oscillator. Therefore, one of the first things to investigate, after noting a complete failure to count in the TEST position, is the oscillator.

Look at the oscillator sub-chassis to be sure that the INT-EXT switch has not been accidentally thrown to the EXT position. Put the scope probe on pin 2 of V402, (or on the FREQ jack on the rear of the instrument): the oscillator output waveform should appear, a distorted sine wave in the range of 10 to 16 volts peak-to-peak. A value of about 12 volts is normal, but the instruments will operate correctly over at least the range noted above. If this waveform is not present, adjust C410, marked "XTAL ADJ" on the chassis. (Upon completion of the repair, don't forget to reset this control so that the oscillator frequency will be precise.) If a spare crystal is available it should be tried as a substitute but with a new crystal the value of C404 may need to be changed as suggested in the manual. Remaining components and wiring can be checked with an ohmmeter.

Located on the same sub-chassis as the oscillator is the shaper circuitry. This section amplifies and shapes the signal generated by the oscillator. If the proper oscillator signal was found to be present when checked with a scope at pin 2 of V402, the oscillator is not at fault and trouble may be found in the shaper. Place the scope probe on pin 1 of V402; a waveform should appear, with a peak-to-peak value of from 12 to 20 volts. The appearance of this waveform will differ in the 100kc and 1mc models, and will also depend on the setting of the SHAPER LEVEL control, R414, located in the pin 2 grid circuit of V402.

After repairing the trouble be sure that the SHAPER LEVEL control is reset properly as described in the manual, but, before doing this, rotate it back and forth, noting whether operation is restored with the FUNCTION switch at TEST. You will find that there is a range of settings within which the instrument will perform correctly, but a setting well to the side of this range may cause entire lack of amplification through the shaper tube. Other points to check are the B supply voltage, the tube and the small choke coil, L402. Other components may be checked in the usual manner. Most component values in the oscillator-shaper circuit are not critical.

TIME BASE DIVIDERS

Be sure to make use of the circuit description and waveforms published in the instruction manual when shooting troubles in the dividers. The amplitudes listed on the waveform photographs are approximate: there is appreciable variation among instruments. It is advisable to become familiar with the adjustment of the dividers before trouble occurs. Practice on an instrument that is known to be in good operation. Put the unit in the TEST function and take note of the readings obtained as the first divider is misadjusted, then the second, the third and so on. An actual trouble will probably occur in a single divider only, so the complication of more than one divider being out of adjustment is rare.

Make certain that the supply voltage of +120 volts is present and well-regulated. Make sure that the input pulses from the oscillator-shaper are entering the divider chain. Use the TIME-SECONDS switch and the readout on the DCU's to pin down the defective stage. Check division ratios with a scope at the points suggested in the manual. A slight adjust-

ment of one divider may bring a unit back to normal, or perhaps the replacement of one tube may have the same result. Do not overlook the possibility that the TIME TRIGGER LEVEL control (R606) is set incorrectly. Aged tubes should be used as replacements in the divider chain in order that the original adjustment will hold for several months or more. Replacements for the 6U8 (V601) should be Sylvania brand for best performance. The adjustment procedure for the dividers and the TIME TRIGGER LEVEL control is well covered in the instruction manual; no further mention will be made here.

The voltages shown in the table on page 6 will be of real help in servicing the dividers. Notice that all the dividers, except V608 (contained in Models 7160 and 7360 only), are identical, so voltages and resistances in one stage may be compared with those in another. A convenient point to monitor the clock pulses is at the TIME jack, located on the rear lip of the chassis.

GATE AND CONTROL CIRCUITRY

Learning How the Circuits Operate. No one can hope to be successful in troubleshooting the control circuitry unless he understands the operating cycle. First, study the circuit description and the cyclic timing diagrams reproduced in the manual. Second, if possible, study the circuitry in a well-functioning instrument while it resets in each of its three stable states: "ready time", "counting time" and "display time". (The fourth state of the operating cycle, the "inhibit start time", is a transient condition lasting only a few milliseconds.) Use the following procedure:

- (a) Rotate the DISPLAY control clockwise until a switch clicks. This prevents the instrument from resetting automatically.
- (b) Place the FUNCTION switch at some position at which an input trigger channel supplies "start" and "stop" pulses, but do not couple an input signal to the channel.
- (c) Press the RESET button. After a brief "inhibit start" period, the circuitry should switch to the "ready time" state. This state may then be studied deliberately with a VTVM.
- (d) Introduce a "start" pulse by rotating the trigger voltage control on the input channel back and forth. The circuitry should then assume the "counting time" state.
- (e) Introduce a "stop" pulse by moving the trigger voltage control back and forth again. This should place the circuitry in the "display time" state.

Troubleshooting. The control circuitry is the most difficult part of the instrument to service; therefore, be sure it is receiving adequate input signals ("start", "stop" and "count" pulses) before beginning to search for trouble. The following troubleshooting procedure is recommended.

- Step 1. Observe signal at control grid of gate tube (V204, pin 1). Pulses to be counted should appear here. If not the DCU's will not count even though the control circuitry is functioning perfectly.
- Step 2. Observe the d-c voltage change at the gating grid (V204, pin 7) while the control circuitry is receiving start and stop pulses separated by one second or more and is adjusted to reset automatically. If the d-c voltage switches back and forth from -15v or more negative to ground level or more positive, the control circuitry is operating all right. In this case inspect the gate tube and associated components for defects. If a sufficient voltage change fails to appear, proceed to step 3.
- Step 3. Attempt to place the control circuitry in the "ready time" state by following steps (a) thru (c) above. If the DCU's do not reset, search for trouble in the reset circuitry (V205 & V206). In particular, inspect diodes CR205 and CR209. If the reset line has been accidentally shorted to ground these diodes may burn out. If the DCU's reset correctly proceed to step 4.
- Step 4. See whether the reset pulse has switched the control circuit binaries to the "ready

time" state. The d-c voltage at pin 1 of both V202 and V203 should be about -47v. If voltages approximating these fail to appear, check the tubes and associated circuitry. If adequate voltages appear, proceed to step 5.

- Step 5. Try to switch the binaries to the "counting time" state by introducing a start pulse as described under (d) above. Both binaries should change state, causing the d-c voltage at pin 1 of both V202 and V203 to change to approximately -10v. If either binary fails to "flip", the tube or associated components may be at fault. The cause may also be one of the injection diodes (CR211 or CR212). Check voltages and components using ordinary techniques, but do not attempt to measure grid voltages on either binary because touching a grid pin with a probe may in itself "flip" the binary. If both binaries have changed state proceed to step 6.
- Step 6. Attempt to place the circuitry in the "display time" state by injecting a stop pulse as described in (e) above. The control binary should change state, causing the voltage at pin 1 of V203 to return to approximately -47v. The automatic reset action begins when a stop pulse occurs. If you adjust the counter for an automatic display period of 4 or 5 seconds, you may check this action by observing the gradually rising voltage at pin 7 of V206. The voltage there should change from about -1v to +20v.

TYPICAL VOLTAGES AND RESISTANCES

The following voltages and resistances appear in a Model 7360. The table is valid for all other 7000 Series instruments (Models 7050, 7060, 7150, 7160, 7250, 7260, 7350 and 7360) except that some of the tubes or other plug-in components listed will not be installed in the instrument. The resulting lower load on the power supply may cause unregulated voltages to rise 5%. Ordinarily, readings may vary $\pm 10\%$ from the typical value without causing trouble. Special conditions of measurement are indicated by letter superscripts ("a", "b", "c", etc.) which refer to notes at the end of the table. Otherwise conditions are as follows:

1. Voltages measured with a VTVM having an input impedance of 11 megohms.
2. Line voltage 117 volts.
3. FUNCTION switch at OFF.
4. TIME switch at 10^{-6} .
5. ATTENUATION controls at "DC1".
6. DISPLAY control turned clockwise until switch clicks.
7. Instrument in "ready time" state; that is, after reset but before a start pulse occurs.
8. No input signals coupled to the instrument.

D-C Supplies	DC Volts with respect to ground	Resistance to ground in Ohms	Plug- in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
Unreg. B+	+200	7.4K				
Reg. B+	+120	4.5K	A202	Same as A205		
Unreg. B-	-116	7.8K	A203	Same as A205		
Reg. B-	-54 to -66	8.1K	A204	Same as A205		

Plug- in DCU	Pin No.						
A201	1	Fil -116	7.3K	A205	1	Fil -116	7.5K
	2	-116	7.5K		2	-38	1.5M
	3	-116	8.9K		3	-116	7.5K
	4	-60	68K		4	-54	66K
	5	+210	7.5K		5	+210	7.5K
	6	N. C.			6	-51	1.42M
	7	210	30K		7	-54	63K
	8	-114	7.3K		8	-116	7.4K
	9	N. C.			9	-49	1.46M
	10	+21	∞		10	-48	1.46M
	11	Fil -116	7.6K		11	Fil -116	7.5K

Plug- in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms	Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A206	1	Fil -116	7.5K	V202	1	-47/-9/-3 ^{cd}	11K
	2	-39	1.5M		2	-82/-92/-92	34K
	3	-116	7.5K		3	-80	18K
	4	-54	63K		4	Fil	
	5	+210	7.5K		5	Fil	
	6	-51	1.42M		6	-11/-48/-48	11K
	7	+89	16.8K		7	-91/-81/-81	42K
	8	-116	7.4K		8	-80	18K
	9	-50	1.42M		9	Fil	
	10	-48	1.44M				
	11	Fil -116	7.5K				
A207	1	Fil		V203	1	-47/-10/-47	5.8K
	2	-20	580K		2	-92/-101/-91 ^{cd}	21K
	3	0	0		3	-91/-92/-91 ^{cd}	12K
	4	+89	16.8K		4	Fil	
	5	+210	7.5K		5	Fil	
	6	+13.5	660K		6	-11/-54/-11 ^{cd}	7.2K
	7	+119	5.5K		7	-99/-91/-99 ^{cd}	42K
	8	+0.55	300 ^b		8	-91/-92/-91 ^c	12K
	9	-29	570K		9	Fil	
	10	-18	650K				
	11	Fil					
Tube V101	1	-2.1	470K	V204	1	-5.3/-6.4/-6.4 ^c	22K
	2	0	0		2	0	0
	3	Fil			3	Fil	
	4	Fil			4	Fil	
	5	+90	110K		5	+120	5.8K
	6	+92	28K		6	+120/+118/+116 ^c	5.9K
	7	0	0		7	-18/+0.3/-18 ^c	200 ^b
V102	1	+87	110K	V205	1	+40/+37.5/+200 ^c	82K
	2	+210	7.5K		2	-0.5/-0.5/-28 ^c	320K
	3	+120	4.8K		3	0	0
	4	+85	110K		4	Fil	
	5	+210	7.5K		5	Fil	
	6	+120	4.8K		6	+210	7.5K
	7	Fil			7	-37.5/-37.5/+40 ^c	605K
	8	Fil			8	-32	25K
					9	Fil	

<u>Tube</u>	<u>Pin No.</u>	<u>DC Volts with respect to ground</u>	<u>Resistance to ground in Ohms</u>	<u>Tube</u>	<u>Pin No.</u>	<u>DC Volts with respect to ground</u>	<u>Resistance to ground in Ohms</u>
V206	1	+61	25K	V303	1	+119/ +119 ^f	5. 1K
	2	+32	4. 4M		2	+50/ +52 ^f	17K
	3	+32	3. 3K		3	+110	5. 1K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+210	61K		6	+92/ +91 ^f	7. 5K
	7	-1/ -1/ +20 ^{ce}	8. 5M		7	+61/ +62 ^f	
	8	+32	3. 3K		8	+61/ +62 ^f	6. 8K
	9	0			9	+59/ +58 ^f	10. 0K
V207	1	+93	18. 5K	V401	1	+88	63K
	2	+13	530K		2	0	115K
	3	+13	1. 0K		3	+116	5. 1K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+210	32K		6	+116	5. 2K
	7	0	24K		7	+3. 1	680K
	8	+13	1. 0K		8	0	0
	9	Fil			9	-3. 6	2. 7M
V301	1	+79/ +82 ^f	14. 5K	XY401 (crystal)	1	117 AC	
	2	+2. 1/ -1. 7 ^f	varies w/ setting of trigger voltage potentiometer		2	N. C.	
	3	+5. 3/ +2. 9 ^f	28K		3	N. C.	
	4	Fil			4	N. C.	
	5	Fil			5	0	0
	6	+88/ +87 ^f	14. 5K		6	117 AC	0
	7	-99	10M		7	+89	63K
	8	+5. 3/ +2. 9 ^f	28K		8	0	∞
	9	Fil					
V302	1	+50/ +52 ^f	17K	V402	1	+116	5K
	2	-3. 5/ -3. 9 ^f	69K		2	+58	47K
	3	+1. 75/ +2. 10 ^f	18K		3	+116	5K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+69/ +68. 5 ^f	12K		6	+92	7. 5K
	7	-2. 9/ -1. 9 ^f	69K		7	+62	6. 8K
	8	+1. 75/ +210 ^f	18K		8	+62	6. 8K
	9	Fil			9	+58	9. 5K

<u>Tube</u>	<u>Pin No.</u>	<u>DC Volts with respect to ground</u>	<u>Resistance to ground in Ohms</u>	<u>Tube</u>	<u>Pin No.</u>	<u>DC Volts with respect to ground</u>	<u>Resistance to ground in Ohms</u>
V601	1	+120	4.2K	V605	1	+65	26K
	2	+58	45K		2	+22	118K
	3	+115	5.0K		3	+24	8.2K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+83	7.2K		6	+105	25K
	7	+59	7.1K		7	-1.7	4.0M
	8	+59	7.1K		8	+24	8.2K
	9	+50	8.8K		9	Fil	
V602	1	+67	25K	V606	1	+66 $\pm 10^g$	26K
	2	+22.5	120K		2	+22 $\pm 2^g$	118K
	3	+24	8.2K		3	+25 $\pm 1^g$	8.2K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+104	25K		6	+105 $\pm 11^g$	26K
	7	+5.2	4.1M		7	-4 $\pm 16^g$	4.0M
	8	+24	8.2K		8	+25 $\pm 1^g$	8.2K
	9	Fil			9	Fil	
V603	1	+106	26K	V607	1	+120	4.6K
	2	+2.0	4.1M		2	+54	58K
	3	+24	8.2K		3	+54	15K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+105 +66	25K		6	+23.5	4.0K
	7	+22.5	120K		7	+23.5	4.0K
	8	+24	8.2K		8	+29	30K
	9	Fil			9	Fil	
V604	1	+66	26K	V608	1	+109	7.3K
	2	+21.5	120K		2	+19	11.5K
	3	+24	8.2K		3	+24	5.0K
	4	Fil			4	Fil	
	5	Fil			5	Fil	
	6	+106	26K		6	+85	7.6K
	7	+0.8	4.1M		7	+29	30K
	8	+24	8.2K		8	+24	5.0K
	9	Fil			9	Fil	

Notes

- a. This DCU is installed only on instruments which feature "X10" positions of the FUNCTION switch.
- b. Resistance reading here will vary with amplitude and polarity of the voltage applied by the measuring device. This reading was obtained using an RCA type WV-98A Volt-Ohmyst on the RX 100 range, negative terminal grounded.
- c. Three voltage reading taken: the first with the instrument in "ready time" state; the second, in "counting time" state, the third, in "displaytime" state.
- d. This pin is connected to a binary grid or plate. If you touch the pin with a probe, the binary may "flip", thus producing a wrong reading. Therefore, when measuring the voltage here attach the probe first, then cause the instrument to pass through the three stable states in the operating cycle.
- e. To obtain the third reading place the instrument in the "display time" state with display control in ∞ position, then rotate the DISPLAY control CCW just far enough to cause the switch to click. The voltage should begin rising from ground level, reaching about +20v in approximately ten seconds.
- f. Two voltage readings taken: the first with the associated TRIGGER VOLTAGE control fully clockwise; the second, with the control fully CCW.
- g. This divider stage cycles so slowly that the needle of a voltmeter will wobble visibly within the range noted.

NOTE

Modified instruments are identified by one or more letters after the model number, each letter standing for one of the modifications described. For example, the Model 7150DR is a standard 7150 that has been modified to incorporate an oven-controlled crystal instead of an unheated crystal (Modification D) and is fitted for rack mounting (Modification R).

Some modifications in this section may not appear in alphabetical order.

Not all the modifications described are applicable to every instrument. For information on suitable modifications, get in touch with the factory or with any of the Beckman representatives listed at the back of the manual.

MODIFICATION B

Modification B extends the count capacity by a factor of 10 or divides the frequency of the start and stop pulses by 10.

Models 7151, 7351, 8151, and 8351

A Model 775Z (Model 777Z for 8151 and 8351), A705, is placed between the Divider Input Gate, V701, and DCU A704. When switch S206 is in the "N X 10" position, A705 divides the digital divider drive pulses by 10, raising the maxi-

imum input frequency from 10 kc to 100 kc. In the "N X 1" position, the instrument works as if unmodified. The circuit changes are shown in Figure B.

Other Models

The schematic diagrams of the other instruments for which modification B is available show the modified circuitry.

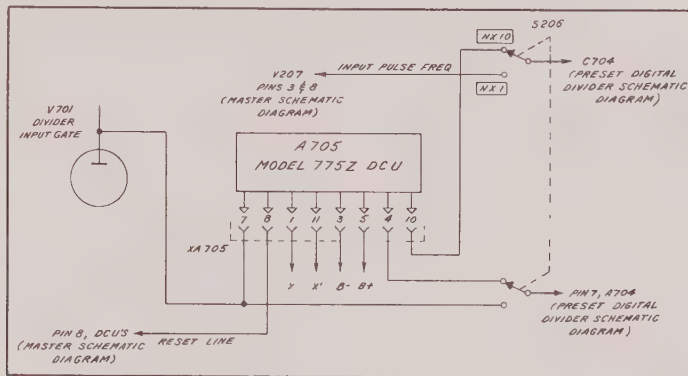


FIG. B. Circuit changes for modification B in Models 7151, 7351, 8151, and 8351.

MODIFICATION C

An instrument with modification C has a mechanical register that extends the count capacity by three extra digits. The register coil is the plate load of a one-shot multivibrator, V21 driven by the output signal of DCU A202; thus, the register records one count for every output pulse of the DCU.

The register is reset manually by a small lever on the front panel just below the register dials and is not affected by the electronic signal that resets the DCU's.

In C-modified instruments with "X 10" modes of operation, the count-indicating panel of the DCU Divider, A201, is not exposed to view, and the digit normally displayed by A201 appears as the right-hand digit of the register.

When A202 resets, it may give an output pulse. To stop this from registering, the reset line is connected to the control grid, pin 2, of V21 so that the inverted reset pulse appearing at the plate, pin 1, suppresses the false count.

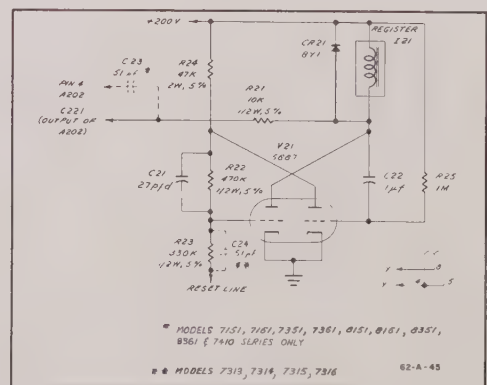


FIG. C. Circuit of modification C.

MODIFICATION D

The frequency stability of the clock pulse generator in instruments using an unheated crystal is 1 part in 10^5 per day. Modification D substitutes a temperature-controlled crystal for the unheated type and improves the oscillator stability to 1 part in 10^6 per day.

Power for the heating element in the crystal oven is taken from one of the filament circuits in the instrument (the circuit that has one side grounded). The circuitry is shown on the crystal oscillator schematic diagrams of the instruments concerned.

MODIFICATION H

Instruments with this modification have a power transformer with a 222-volt primary instead of the standard 117-volt, the primary being two windings in series, a 117-volt and a 105-volt. The line fuses, F101 and F102, have one-half the current rating of those in the standard instruments. Figure H-1 shows the modified circuitry. Note that in instruments with a 1 Mc heated crystal in the oscillator, the crystal oven no longer begins heating as soon as the line cord is plugged into a power receptacle, but heats only when the POWER switch is on.

If operation on 210 volts or 231 volts is desired,

take the wire off terminal 2 of the transformer and connect this wire to terminal 14 or 11 respectively.

To convert to 117-volt operation, rewire the transformer connections as shown in Figure H-2 and replace F101 and F102 with fuses of twice the current rating.

If an instrument with the H modification also has an N modification, refer to the N modification section for further details on power transformer and wiring changes.

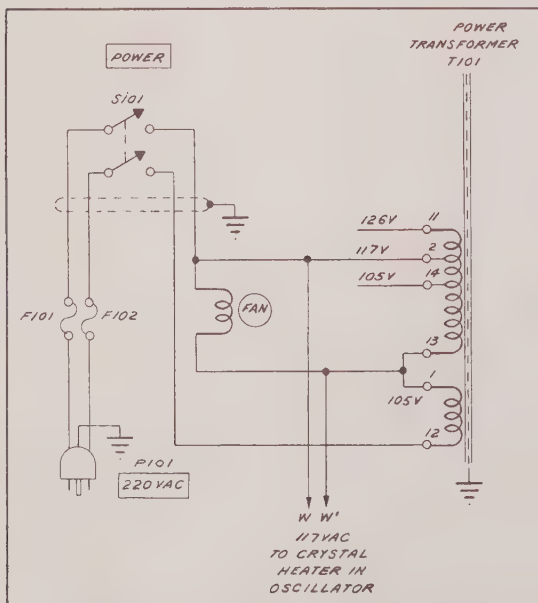


FIG. H-1. Circuit changes in power supply for modification H.

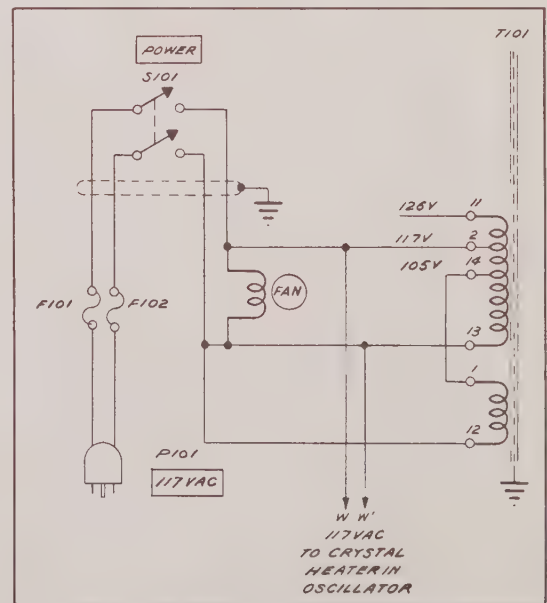


FIG. H-2. Rewiring modification H to operate on 117 volts ac.

MODIFICATION K

To increase the input sensitivity of a counter from 100 mv rms to 5 mv rms, a step-up transformer is inserted between the attenuator and the first grid of any input channel used in count modes. The transformer is put in or out of circuit by a front panel switch (S350) marked HIGH (transformer in) and NORM (transformer out and attenuator connected straight through to the first grid). It should be switched in only if the input signal is below the sensitivity of the counter.

With the transformer connected, the ATTENUATION control should be at DC-1. Under these conditions the input impedance will vary with frequency, rising from at least 300 ohms at 5 cps to about 25K ohms at 10 kc. Sensitivity is at least 5 mv over this range.

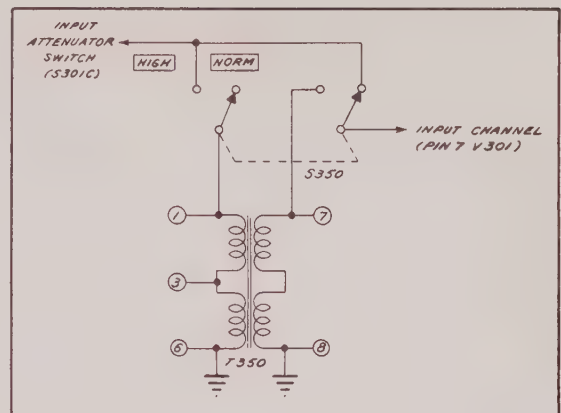


FIG. K. Circuit diagram for modification K.

MODIFICATION L

Applicable to Preset EPUT® Meters or Preset Universal EPUT® and Timers, this modification permits remote control of the digital divider setting, as well as normal control from the front panel.

The sockets of the digital divider DCU's are wired to a female connector (J801) on the rear chassis lip. One matching plug, on a flexible lead coming out of the rear lip, is wired to the

internal preset switches; another is provided for wiring to remote preset switches. Front panel control or remote control is obtained by inserting the appropriate plug into J801.

Figure L shows the internal connections to J801 and gives the recommended wiring of a manually-operated external preset switch. In this application the voltages at pins 21, 22, and 23 of J801 are not used.

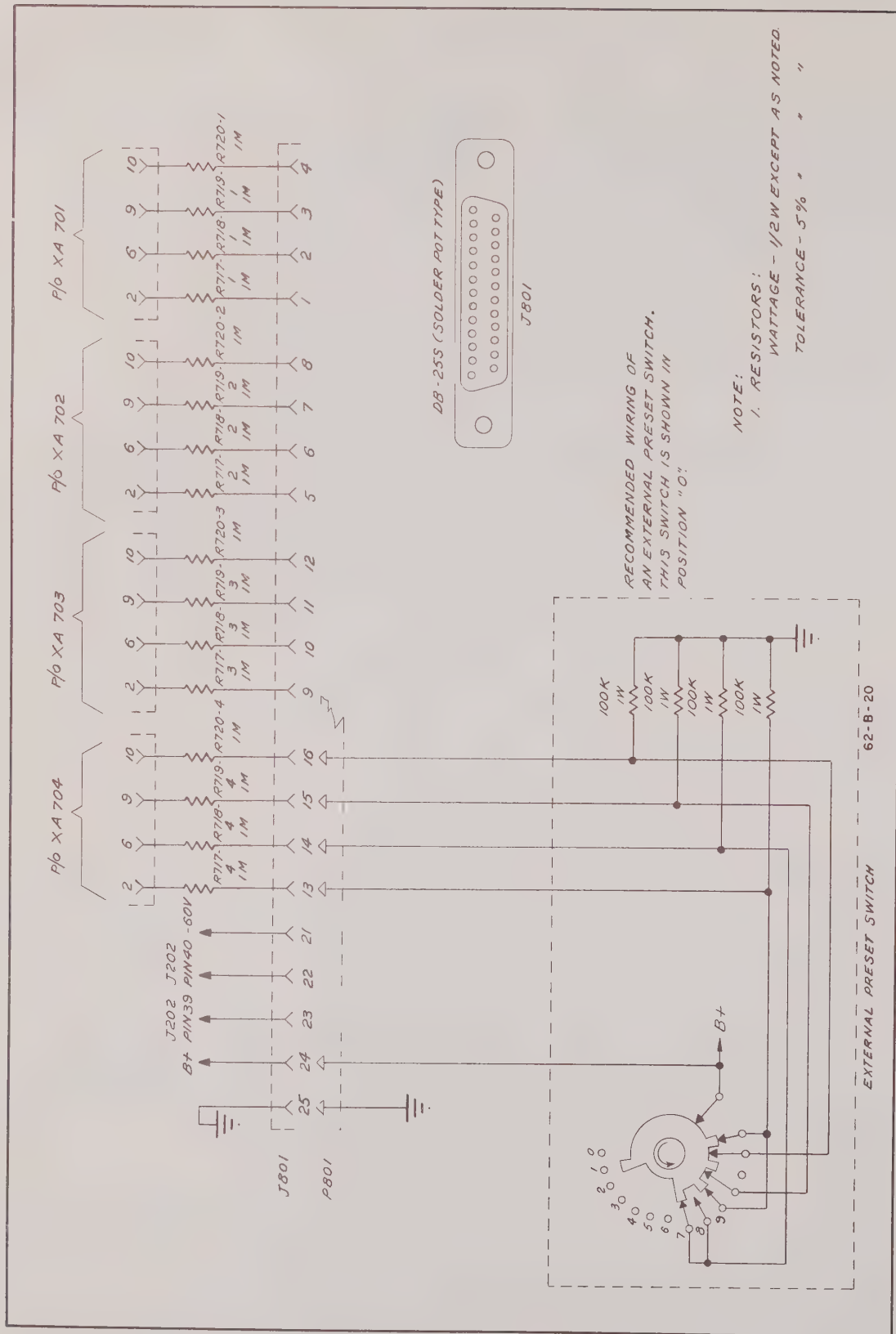


FIG. L. Wiring diagram for modification L.

MODIFICATION N

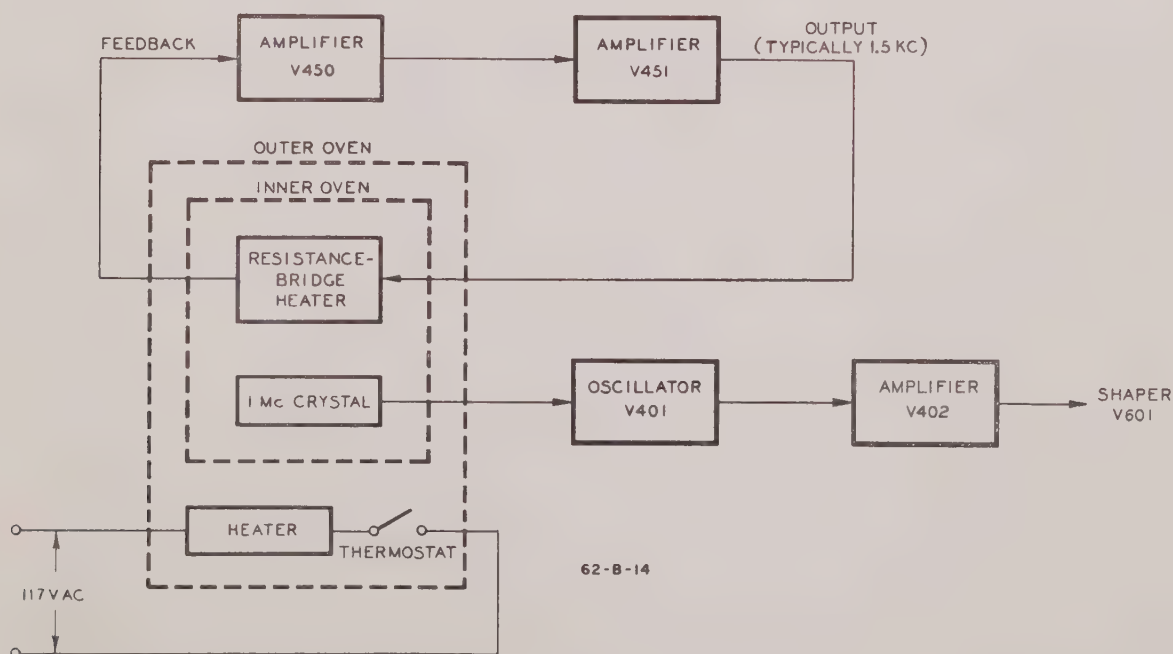
1. GENERAL DESCRIPTION

The N modification, shown in block diagram form in Figure N-1, provides an oscillator stability of 5 parts in 10^8 per week in contrast to the 3 parts in 10^7 per week of the unmodified instruments.

In place of the 1 Mc crystal oven unit that plugs into the oscillator section, instruments with this modification have a double oven mounted on the oscillator chassis. The outer oven is heated by a 117 volt element, thermostatically controlled to stay within 2°C of a nominal 70°C . Inside this oven is a second oven whose temperature is kept within approximately 0.005°C of a nominal 75°C by proportional control. The inner oven contains a temperature-stable crystal that provides the 1 Mc standard for the time base generator in the instrument. As shown in Figure N-3, the circuit of the crystal oscillator (V401) is changed and an amplifier stage (V402) is inserted between the oscillator and the shaper.

In addition, the shaper (now V601 instead of V402) is moved to the frequency divider chassis.

The heating element for the inner oven is a resistance bridge energized by the output of an amplifier (V450 and V451) located on the power supply chassis (see Figure N-3). Two opposite arms of the bridge are made of wire whose resistance changes in proportion to temperature; the other two arms are relatively insensitive to temperature changes. Amplifier and bridge form a closed-loop oscillatory circuit, the error signal from the unbalanced bridge being fed back to the amplifier input in proportion to the temperature difference between the actual and the design temperature of the oven. Since there is a continuous loss of heat from the inner to the outer oven, temperature control of the inner oven is uninterrupted. Thus, the temperature variations normally resulting from the cyclic character of thermostatic control are avoided.



62-B-14

FIG. N-1. Block diagram of modification N.

1.2 OSCILLATOR ADJUSTMENTS

Oscillator adjustments are seldom required for N modifications, except when tubes or components are replaced. An adjustment procedure is given in this N modification section.

There are two adjustments in the N modification: frequency and amplitude. Frequency adjustments are made by varying C405; amplitude adjustments by tuning L401. Adjust L401 first since it has a slight effect on the oscillator frequency.

If the oscillator does not work properly, check supply voltages, tubes and components with the aid of schematic diagram, Figure N-3. When the oscillator is working, but slightly out of adjustment – either from normal use or servicing – use this procedure:

a) Adjustment of L401

- 1) Remove the bottom cover from the N modification assembly as shown in Figure N-2 and locate the L401 adjustment.
- 2) Use a VTVM to measure from the junction of R410 and R411 (see Figure N-2) to ground. Use minus polarity.

- 3) Tune L401 for maximum voltage. The voltage range should vary from -4 to -12 volts depending on the resonant impedance of the crystal, and characteristics of tube V401.

NOTE

Since tuning is broad, the center of adjustment can be found by rotating the tuning slug midway between the positions that cause a noticeable decrease in voltage. Inductor L401 should not be used as a frequency setting adjustment.

b) Adjustment of C405

The oscillator frequency is set at the factory. The stability is 5 parts in 10^8 per week, therefore, do not adjust unless a frequency standard at least that accurate is available. If a precise 1 Mc standard is available, follow these steps:

- 1) Use Figure N-2 as a guide to locate trimmer adjustment C405.
- 2) Connect the output from FREQ Jack J401 to the vertical input of an oscilloscope. Then, couple a 1 Mc standard to the horizontal input and adjust C405 for a Lissajous pattern indicating equal frequency.

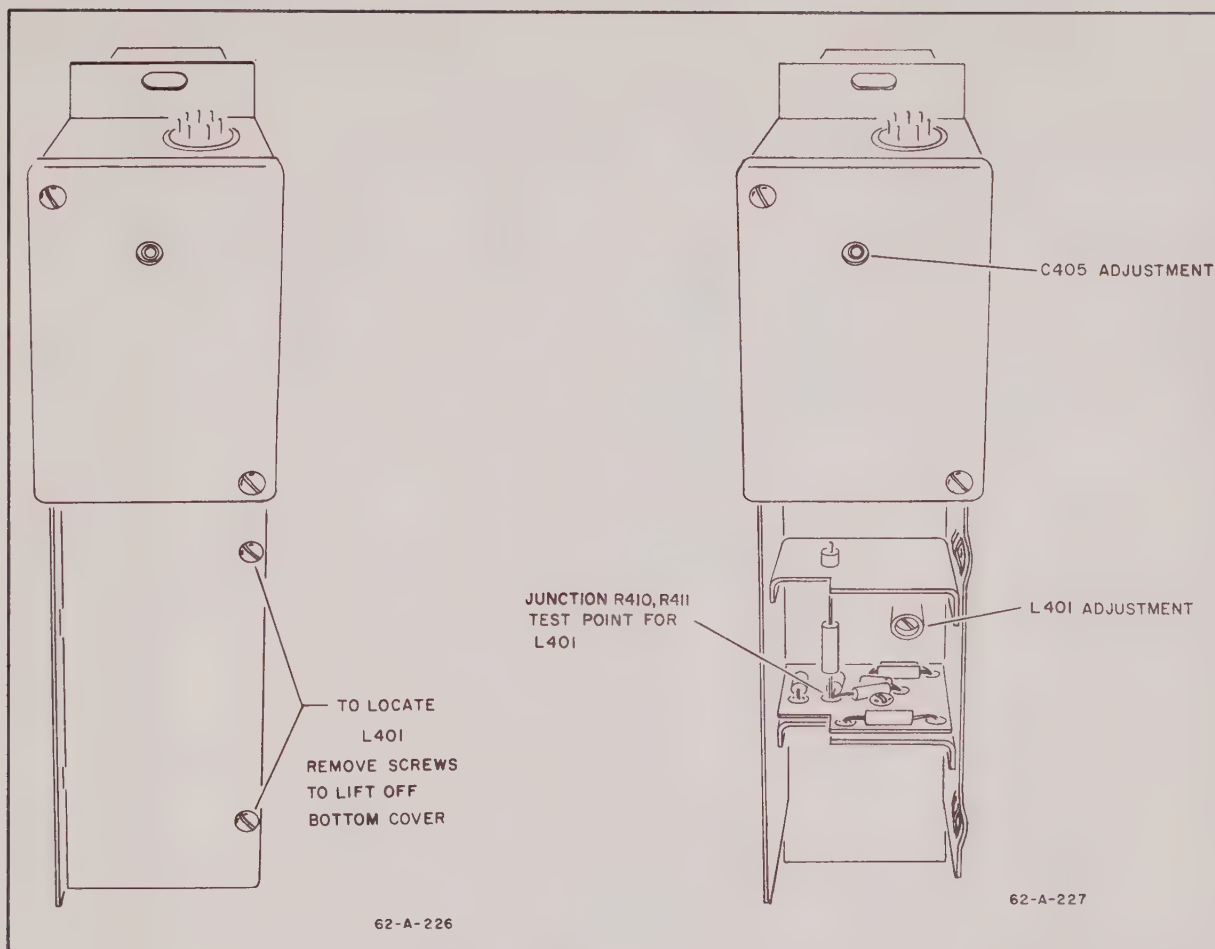


FIG. N-2. Illustrates location of N modification adjustments.
Underchassis view.

Instruments having both the H and N modifications require a different power transformer for the N modification. A power transformer is used with a 222-volt primary instead of the standard 117-volt, the primary being two windings in series, a 117-volt and a 105-volt. The line fuses, F450 and F451, have one-half the current rating of those in the standard N modification. If operation on 210 volts or 231 volts is desired, take the wire off terminal 3 of the

transformer and connect this wire to terminal 2 or 4 respectively. Figure HN-1 shows the modified circuitry.

To convert to 117-volt operation, rewire the transformer connections as shown in Figure HN-2 and replace F450 and F451 with fuses of twice the current rating. The correct current rating is listed on the power supply schematic diagrams of the instruments.

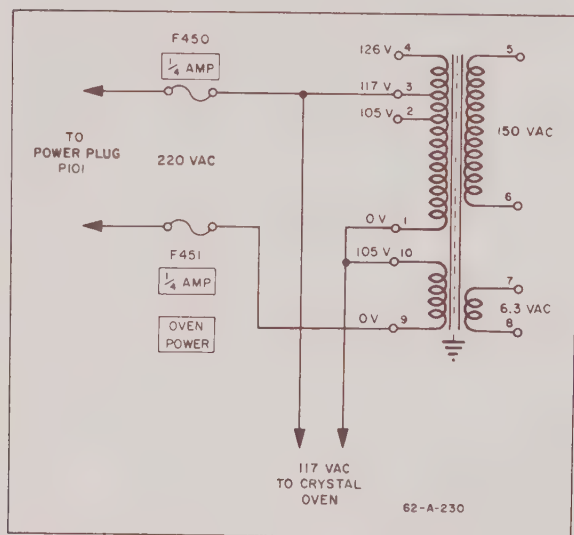


FIG. HN-1. Circuit changes in power supply for 220 volt operation.

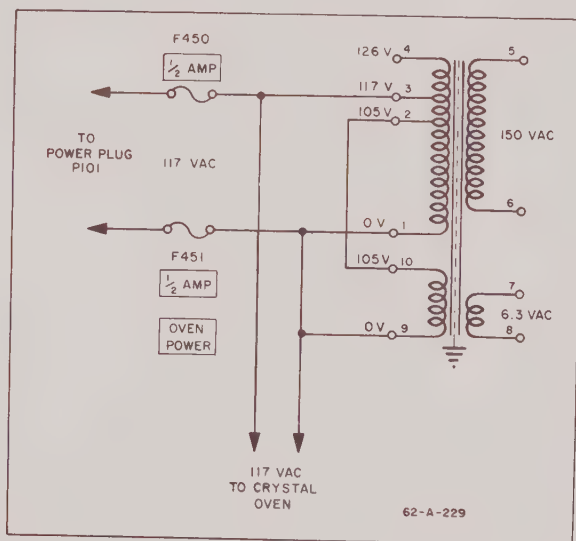
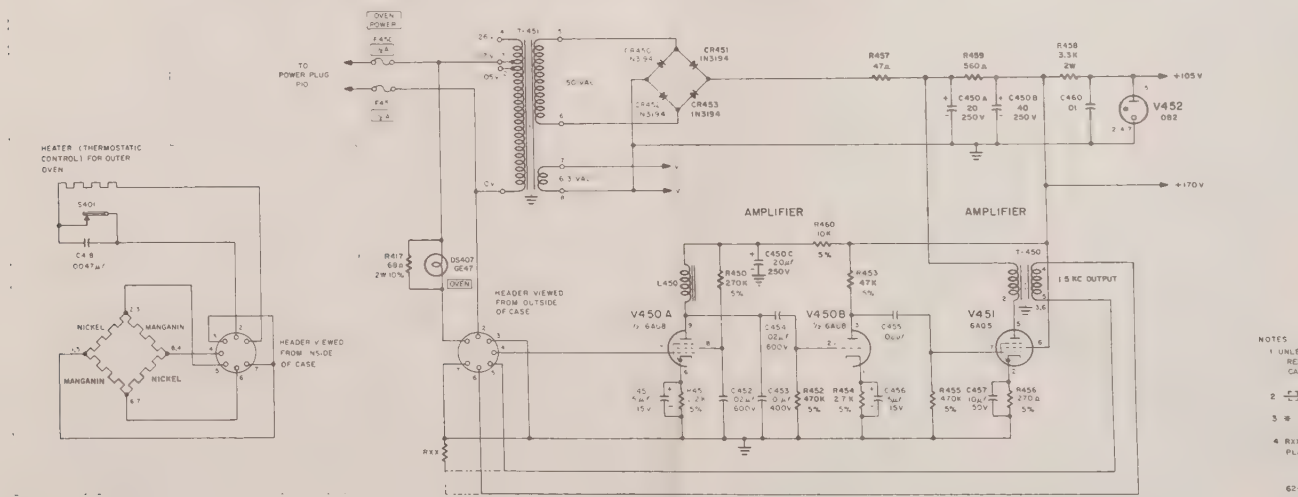
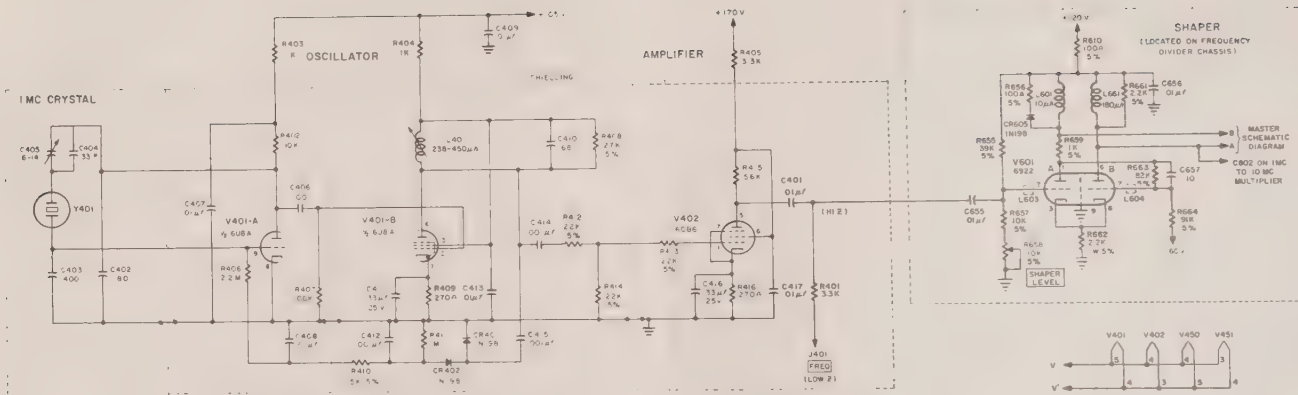


FIG. HN-2. Rewiring power supply for 117 volt operation.



- NOTES
- 1 UNLESS OTHERWISE NOTED: RESISTORS ARE IN OHMS, $\frac{1}{2}$ W, 10% CAPACITORS ARE IN PICOFARADS
 - 2 $\frac{1}{2}$ DENOTES FERRITE BEAD
 - 3 * VALUE FACTORY SELECTED
 - 4 R1X, FACTORY SELECTED AND PLACED

FIG. N-3. Oscillator and amplifier in modification N.

MODIFICATION R

Instruments with this modification are intended for mounting in a standard relay rack and are supplied without a cabinet but with a top dust cover. Mounting dimensions are given in Figure R.

The air intake ports in the sides of the chassis

and the exhaust opening at the back should be kept free from obstruction so that the forced-draft cooling system can work efficiently. For the same reason, the dust cover must be kept in place when the instrument is in operation, as overheating can cause serious damage to components.

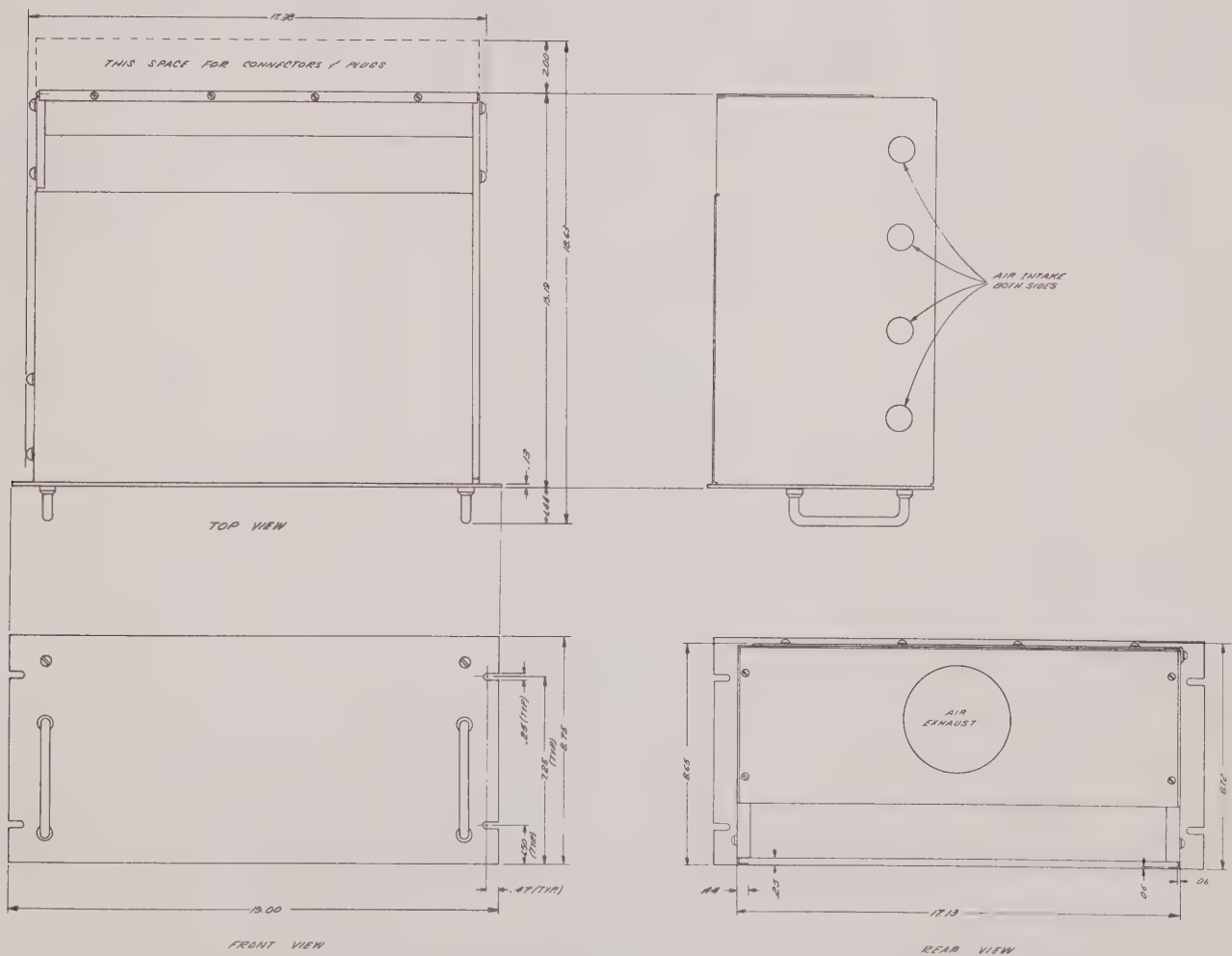


FIG. R. Rack mounting dimensions for 7000 and 8000 model series instruments.

MODIFICATION T

In contrast to the standard Beckman/Berkeley 1-2-2-4 readout code, instruments with the T modification furnish a 1-2-4-8 readout. The modified code is supplied by special DCU's substituted for the standard units. These DCU's

are designated by the letter "R" following the model number.

The only modification to the wiring of the instrument is that pin 35 of the DIGITAL RECORDER connector, J202, is grounded.

MODIFICATION U

Modification U supplies power for auxiliary equipment through an ACCESSORY socket on the rear chassis lip of the instrument.

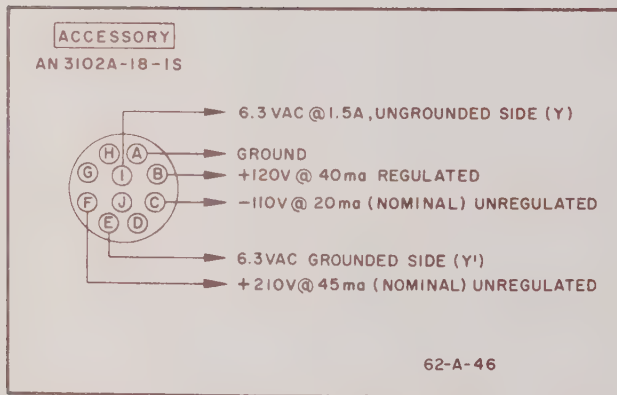


FIG. U. Connections to accessory socket in modification U.

MODIFICATION W

This modification adds a circuit that provides strobe pulses of variable width for external use (see Figure W).

The circuit consists of two identical one-shots (V901 and V902) driven by the "start" and "stop" pulses coming from the FUNCTION switch. One-shot V901 is triggered by "start" pulses, and V902 by "stop" pulses. When one of these negative pulses appears at the input grid (pin 7), the one-shot flips to the quasi-stable state and then back to its stable state. In so doing, it generates a negative output pulse of about 25 volts at one of the plates (pin 1). The duration of the

quasi-stable state, and hence the width of the output pulse, depends on the capacitance put into the circuit by the STROBE PULSE WIDTH switch (S901).

The negative output pulses from the one-shots appear at the STROBES jacks (START, J901, and STOP, J902) on the rear panel of the instrument. Capacitors C201 and C206 are replaced by C919 and C920 respectively. The pulses can be applied to the Z axis of an oscilloscope to intensify the input waveform at the points where the input channel of a counter is being triggered.

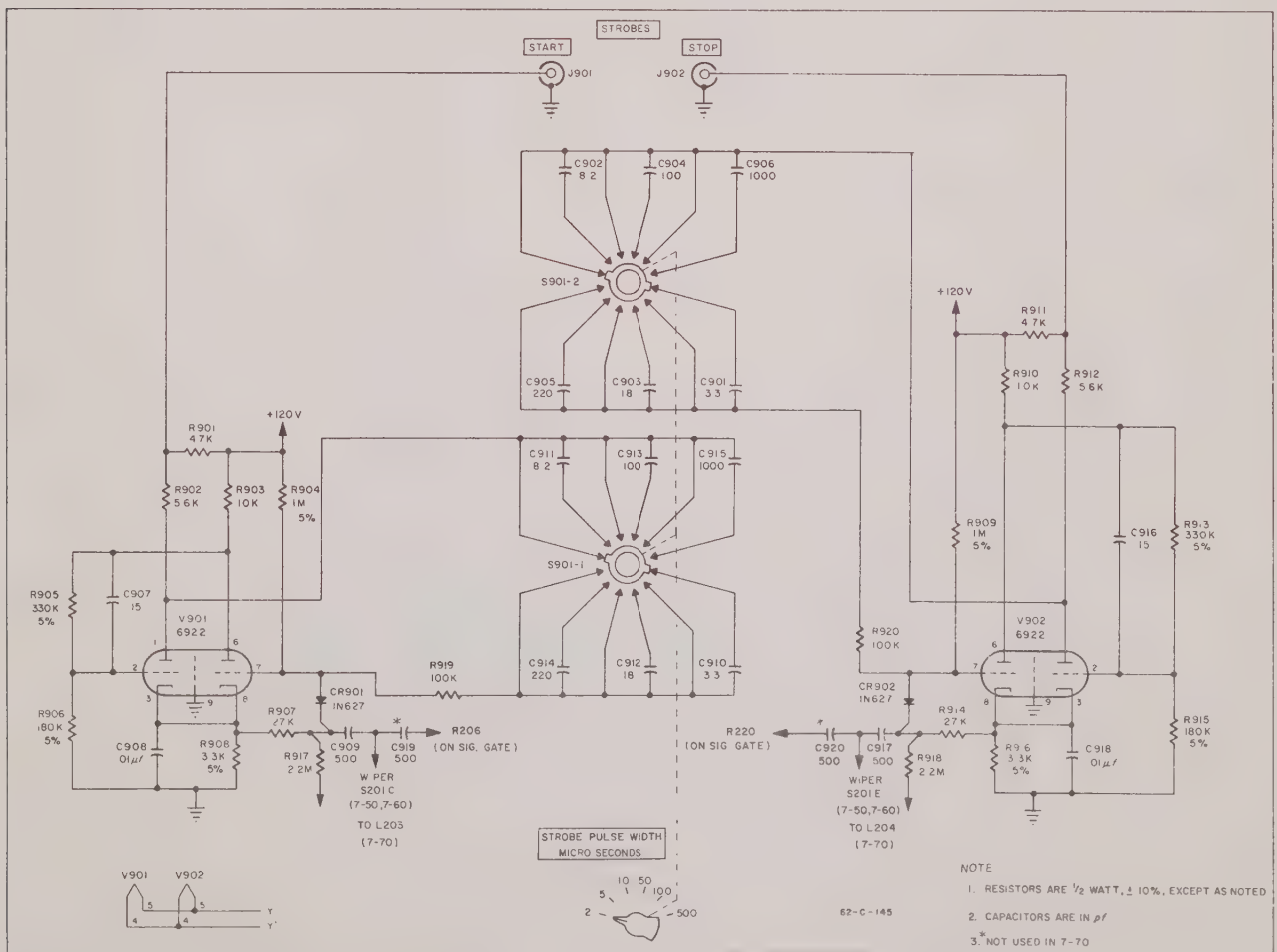


FIG. W. Circuit diagram for modification W.

MODEL 7050 MASTER
SCHEMATIC DIAGRAM

NOTE

Detail No.	Beckman Stock No.	Description	Manufacturer	Detail No.	Beckman Stock No.	Description	Manufacturer
C201	804777	Capacitor, mica, 500 μ f, 300V, 5%	Sangamo	C248		Same as C218	
C202	804744	Capacitor, mica, 33 μ f, 500V, 5%	Sangamo	CR201	404593	Diode	Beckman/Berkeley
C203	804817	Capacitor, paper, 0.25 μ f, 400V, 20%	Sangamo	CR203		Same as CR201	
C204	804717	Capacitor, ceramic, .01 μ f, 500V, +10% -20%	Sprague 29C9	CR204	800272	Diode, 1N95	Hughes
C205		Same as C202		CR205	800273	Diode, 1N96	Hughes
C206		Same as C201		CR206		Same as CR201	
C207	807483	Capacitor, mica, 25 μ f, 500V, 5%	Sangamo	CR207		thru	
C208	804740	Capacitor, mica, 22 μ f, 500V, 5%	Sangamo	CR209		Same as CR204	
C209		Same as C204		CR211	800274	Diode, 1N198	
C210		Same as C208		CR212		Same as CR211	Hughes
C211		Same as C207		CR213		Same as CR201	
C212		Same as C201		J202	808533	Connector, 40 pin, female	Cannon
C213		Same as C204		J203	806914	Connector, tip Jack	Whitco
C214	007487	Capacitor, paper, 0.1 μ f, 400V, 2%	Hopkins P14D	L201	807920	Inductor, 500 μ H	Wilco
C215	804722	Capacitor, ceramic, .02 μ f, 400V, Guaranteed minimum value	Frie	R247	806307	Potentiometer, wirewound, 10M, 1.2W, 20% v/switch S204	Centralab
C216	020038	Capacitor, paper, 1 μ f, 200V	Sprague	S201	402110	Switch, rotary	Beckman/Berkeley
C217	804876	Capacitor, paper, 0.5 μ f, 200V, 20%	Hopkins	S202	808040	Switch, toggle, DPDT	Cutler-Hammer
C218	804718	Capacitor, ceramic, .01 μ f, 450V	Erie	S203		Same as S202	
C219		Same as C201		S204		Switch, part of P247	
C220	807485	Capacitor, mica, 100 μ f, 500V, 5%	Sangamo	S205	043278	Switch, pushbutton, SPDT	Switchcraft
C221	807454	Capacitor, mica, 50 μ f, 500V, 5%	Sangamo	S206	800258	Tube, 5985	
C222		Same as C220		V203		Same as V202	
C223				V204	800223	Tube, 6A86	
C246	804706	Capacitor, ceramic, .001 μ f, 1000V, 20%	Centralab	V205		Same as V202	
C247		Same as C218		V206	800237	Tube, 6DJ8	
				XA202	016990	Socket, 11 pin	Amphenol
				XA203		thru	
				XA207		Same as XA202	
				XV202	802336	Socket, 9 pin	Elco
				XV203		Same as XV202	
				XV204	802323	Socket, 7 pin	Elco
				XV205		Same as XV202	
				XV206		Same as XV202	



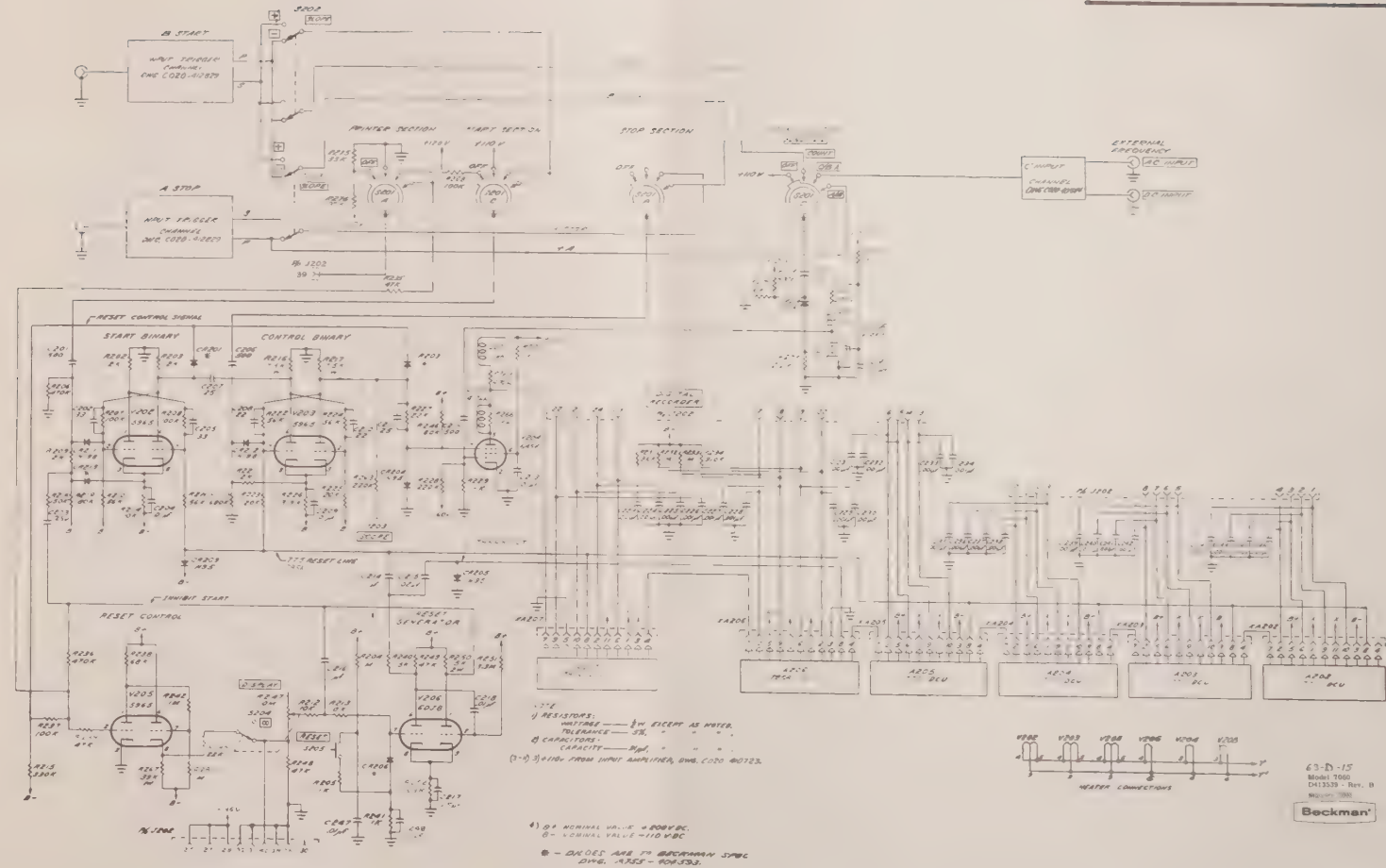
PARTS LIST, MASTER SCHEMATIC DIAGRAM

7050 D 21

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

Detail No.	Beckman Stock No.	Description	Manufacturer	Detail No.	Beckman Stock No.	Description	Manufacturer
C201	804777	Capacitor, mica, 500 μ f, 300V, 5%	Sangamo	C248		Same as C218	
C202	804744	Capacitor, mica, 33 μ f, 500V, 5%	Sangamo	CR201	404593	Diode	Beckman/Berkeley
C203	804917	Capacitor, paper, 0.25 μ f, 400V, 20%	Sangamo	CR203		Same as CR201	
C204	804717	Capacitor, ceramic, .01 μ f, 500V, +80% -20%	Sprague 29C9	CR204	800272	Diode, 1N95	Hughes
C205		Same as C202		CR205	800273	Diode, 1N95	Hughes
C206		Same as C201		CR206		Same as CR201	
C207	807483	Capacitor, mica, 25 μ f, 500V, 5%	Sangamo	CR207		Same as CR204	
C208	904740	Capacitor, mica, 22 μ f, 500V, 5%	Sangamo	CR209		Same as CR211	
C209		Same as C204		CR211	800274	Diode, 1N198	Hughes
C210		Same as C208		CR212		Same as CR211	
C211		Same as C207		CR213		Same as CR201	
C212		Same as C201		J202	806833	Connector, 40 pin, female	Cannon
C213		Same as C204		J203	806914	Connector, tip jack	Whitco
C214	007487	Capacitor, paper, 0.1 μ f, 400V, 2%	Hopkins P14D	L201	807920	Inductor, 500 μ h	Wilco
C215	804722	Capacitor, ceramic, .02 μ f, 500V, Guaranteed minimum value	Erie	R247	806307	Potentiometer, wirewound, 10M, 1/2W, 20% w/switch S204	Centralab
C216	020338	Capacitor, paper, 1 μ f, 200V	Sprague	S201	402110	Switch, rotary	Beckman/Berkeley
C217	804876	Capacitor, paper, 0.5 μ f, 200V, 20%	Hopkins	S202	806040	Switch, toggle, DPDT	Cutler-Hammer
C218	804718	Capacitor, ceramic, .01 μ f, 450V	Erie	S203		Same as S202	
C219		Same as C201		S204		Switch, part of R247	
C220	807486	Capacitor, mica, 100 μ f, 500V, 5%	Sangamo	S205	043278	Switch, pushbutton, SPDT	Switchcraft
C221	807484	Capacitor, mica, 50 μ f, 500V, 5%	Sangamo	V202	800258	Tube, 58S5	
C222		Same as C220		V203		Same as V202	
C223		Same as C220		V204	800223	Tube, 6AS6	
C246	804706	Capacitor, ceramic, .001 μ f, 1000V, 20%	Centralab	V205		Same as V202	
C247		Same as C218		V206	800237	Tube, 6XD5	
				XA202	016990	Socket, 11 pin	Amphenol
				XA203		Same as XA202	
				XV202	802336	Socket, 9 pin	Elco
				XV203		Same as XV202	
				XV204	802323	Socket, 7 pin	Elco
				XV205		Same as XV202	
				XV206		Same as XV202	



PARTS LIST, POWER SUPPLY

Refer to Dwg. No. 7370-62-C-47

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

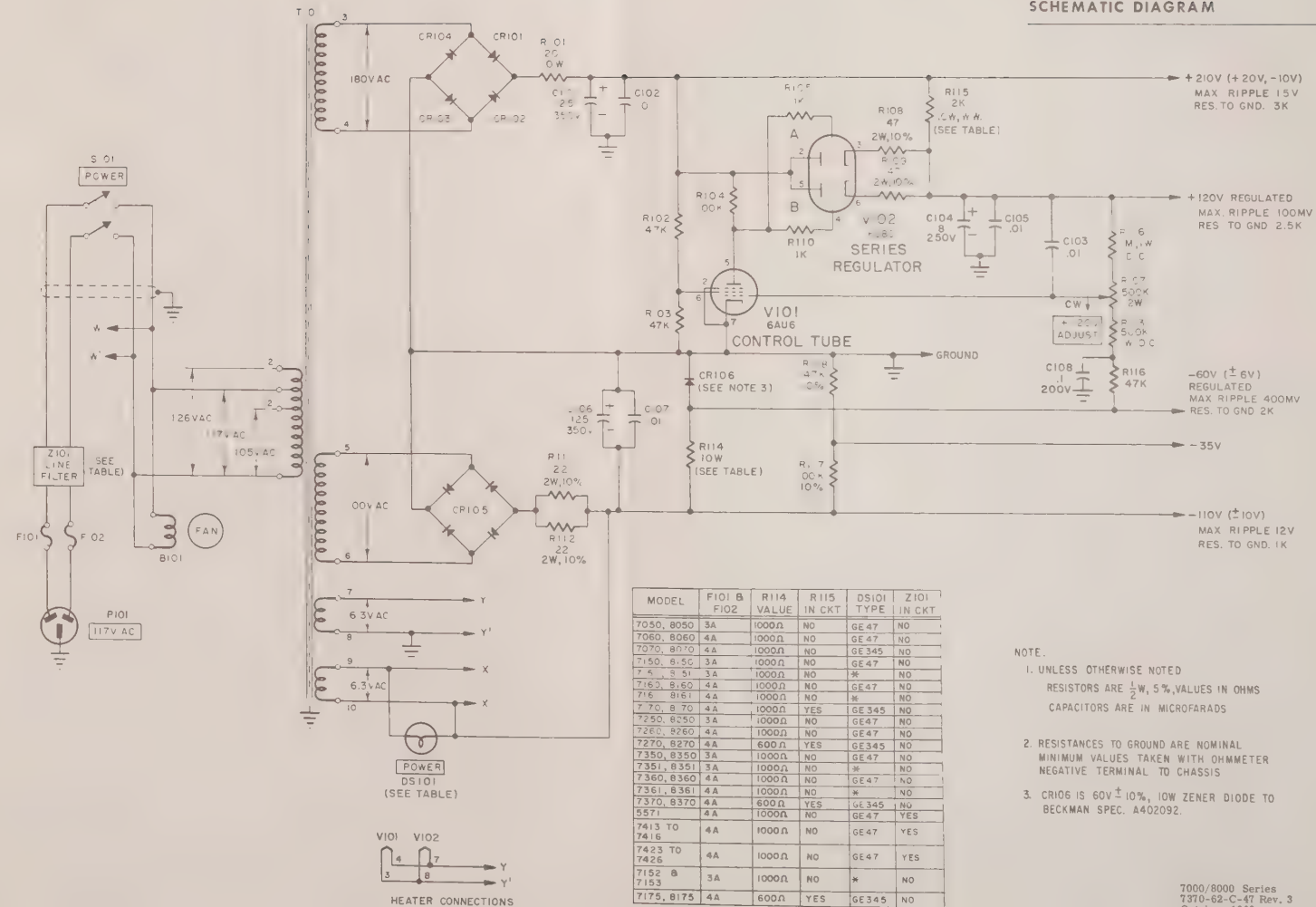
ABBREVIATIONS

AB Allen Bradley Co., Milwaukee, Wis.
B/B Beckman, Berkeley, Richmond, California
CH Cutler-Hammer Co., Milwaukee, Wis.
WW Wirewound

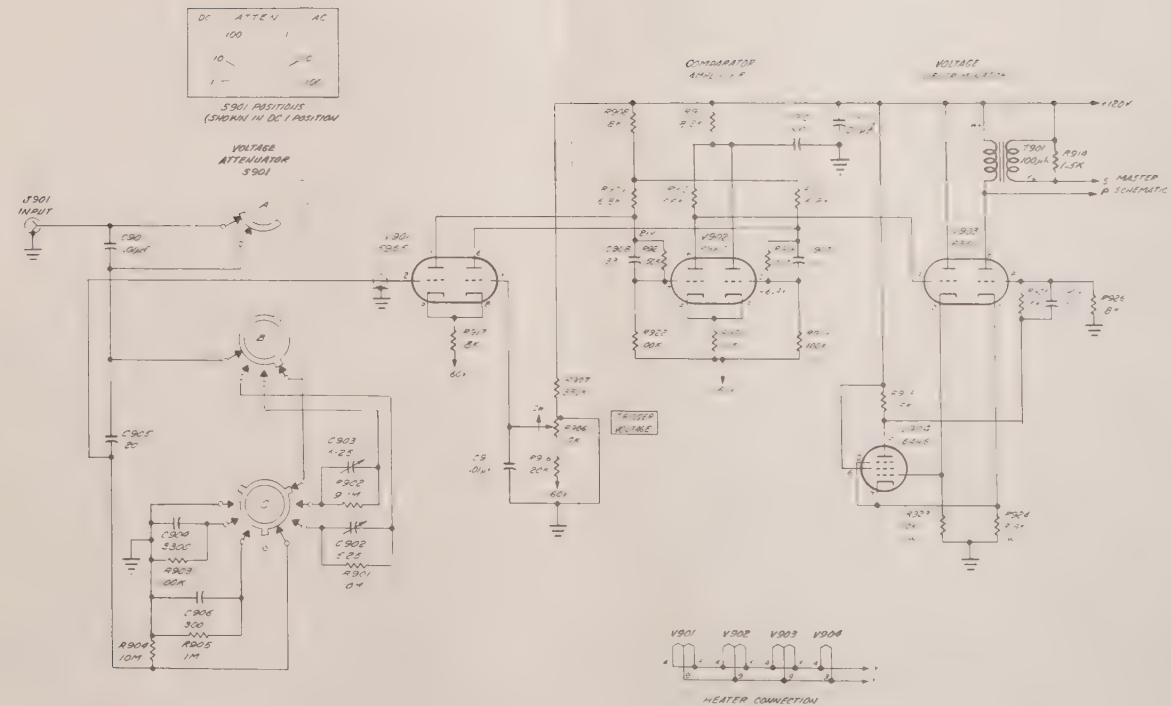
Detail No.	Berkeley Stock No.	Description	Manufacturer & No.	Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
B101	407587	Fan Assembly	B/B	R101	800532	Resistor, 20 Ω , 10W	Tru-Ohm FRL-10
C101	802975	Capacitor, 125 μ f, 350V	Mallory FP140	R106	800913	Resistor, 1M, 1W	Arnhold Ceramics Stenag Type A2
C102	804718	Capacitor, disc., .01 μ f	Erie 811-.01	R107	806335	Potentiometer, 500K, 2W	AB JU 5041 SD3048
C103		Same as C102		R113	801148	Resistor, 500K, 1W	Arnhold Ceramics Stenag Type A2
C104	802946	Capacitor, electrolytic, 5 μ f, 250V	Sangamo MT 2508	R114*	802000	Resistor, WW, 1000 Ω , 10W, 10%	Tru-Ohm FRL-10
C105		Same as C102			002775	Resistor, WW, 600 Ω , 10W	Tru-Ohm FRL-10
C106		Same as C101		R115	800941	Resistor, WW, 2K, 10W	Tru-Ohm FRL-10
C107		Same as C102		S101	806031	Switch, toggle, DPST	CH 8370 K8
C108	091715	Capacitor, 0.1 μ f, 200V, 20%	Sangamo 330201	T101	402952	Transformer, power	B B
CR101	023744	Rectifier, silicon	Sarkes Tarzian M500	V101	015096	Tube, 6AU6	Littelfuse 099062
CR102		Same as CR101		V102	020285	Tube, 6080	
CR103		Same as CR101		XCR101	024849	Spring Clip	
CR104		Same as CR101		XCR102 thru XCR104		Same as XCR101	
CR105	808191	Rectifier, 110V, 130ma	General Electric 6R21PB3AT1			Diode	
CR106	402092	Lamp	B/B		801191	Lamp Socket Assy. w/green lens	Dialight Corp. 81416-422
DB101*	062507	Lamp	General Electric #345	XDB101*	817545	Lamp Socket Assy. w/green lens	Dialight Corp. 111-3830-112
F101*	801574	Fuse, SloBlo, 3 amp, 125V	Littelfuse	XP101	007268	Fuse Post	Bussman HKP
F102	801579	Fuse, SloBlo, 4 amp, 125V	Littelfuse	XF102		Same as XF101	Elco 316BC
				XV101	802323	Tube Socket, 7 pin	Cinch 9950
				XV102	802331	Tube Socket, octal	
				Z101	802473	Line Filter	Sprague 64864

*Type or value depends on instrument model. See table on Power Supply Schematic Diagram.

POWER SUPPLY SCHEMATIC DIAGRAM



"A" OR "B" INPUT CHANNEL SCHEMATIC DIAGRAM



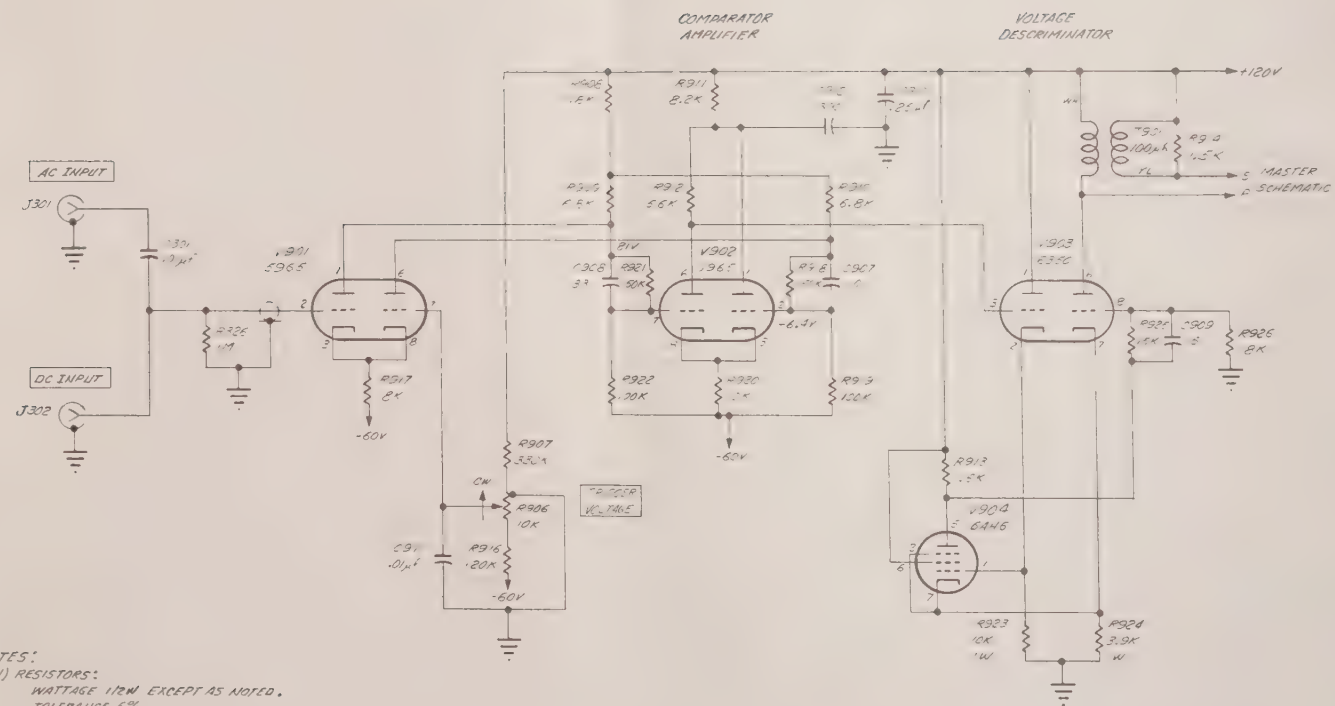
NOTES:

- 1) RESISTORS:
WATTAGE 1/8W EXCEPT AS NOTED.
TOLERANCE 5% " " " "
- 2) CAPACITORS:
CAPACITY IN μ F " " " "

Models:
7060, 7160, 7260, 7360,
8060, 8160, 8260, 8360
C 412829-Rev. C
March, 1963

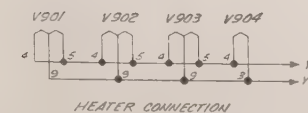
Beckman®

"C" INPUT CHANNEL SCHEMATIC DIAGRAM



NOTES:

- 1) RESISTORS:
WATTAGE 1/2W EXCEPT AS NOTED.
TOLERANCE 5% " " " "
- 2) CAPACITORS:
CAPACITY IN μF EXCEPT AS NOTED.



PARTS LIST, INPUT CHANNEL

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

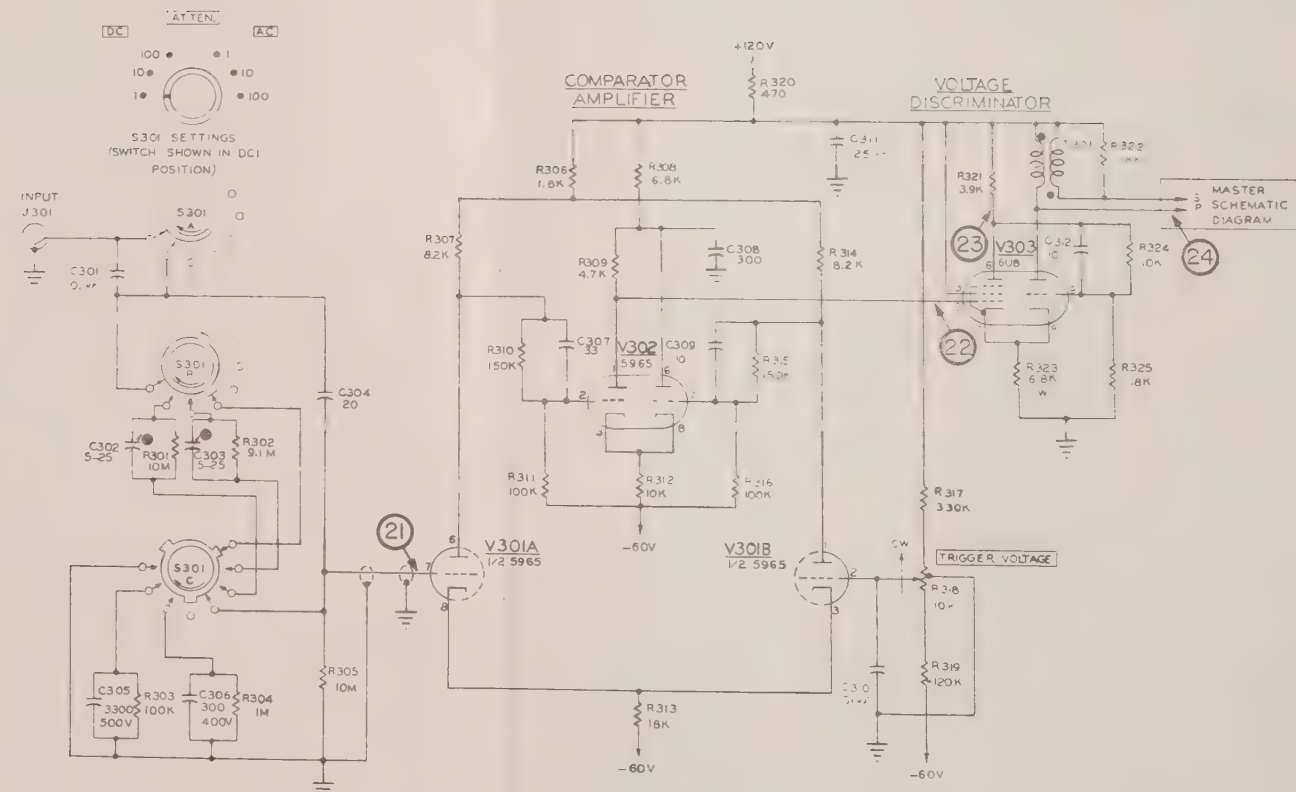
Detail No.	Berkeley Stock No.	Description	Manufacturer	Detail No.	Berkeley Stock No.	Description	Manufacturer
C301	804718	Capacitor, ceramic, .01 μ f, 600V, guaranteed minimum value	Erie	C310		Same as C301	
C302	805005	Capacitor, variable, 5-25 μ f, 500V	Erie	C311	804871	Capacitor, paper, 0.25 μ f, 200V, 20%	Hopkins
C303		Same as C302		C312		Same as C309	
C304	804739	Capacitor, mica, 20 μ f, 500V, 5%	Sangamo	J301	403555	Connector	Beckman Berkeley
C305	804800	Capacitor, mica, 3300 μ f, 500V, 5%	Sangamo	J302		Same as J301	
C306	804768	Capacitor, mica, 300 μ f, 500V, 5%	Sangamo	R138	812445	Potentiometer, 10K, 2W, 20%	Allen Bradley
C307	804744	Capacitor, mica, 33 μ f, 500V, 5%	Sangamo	S301	402101	Switch	Beckman Berkeley
C308		Same as C306		T301	402046	Transformer, pulse, 1:1	Beckman Berkeley
C309	807482	Capacitor, mica, 10 μ f, 500V, 5%	Sangamo	V301	800258	Tube, 5965	
				V302		Same as C301	
				V303	800240	Tube 6U8	
				XV301	802336	Socket, 9 pin	Elco
				XV302		Same as XV301	

September 1962

Beckman

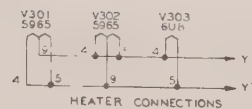
Dwg. No. 62-C-156

INPUT CHANNEL SCHEMATIC DIAGRAM



NOTES:

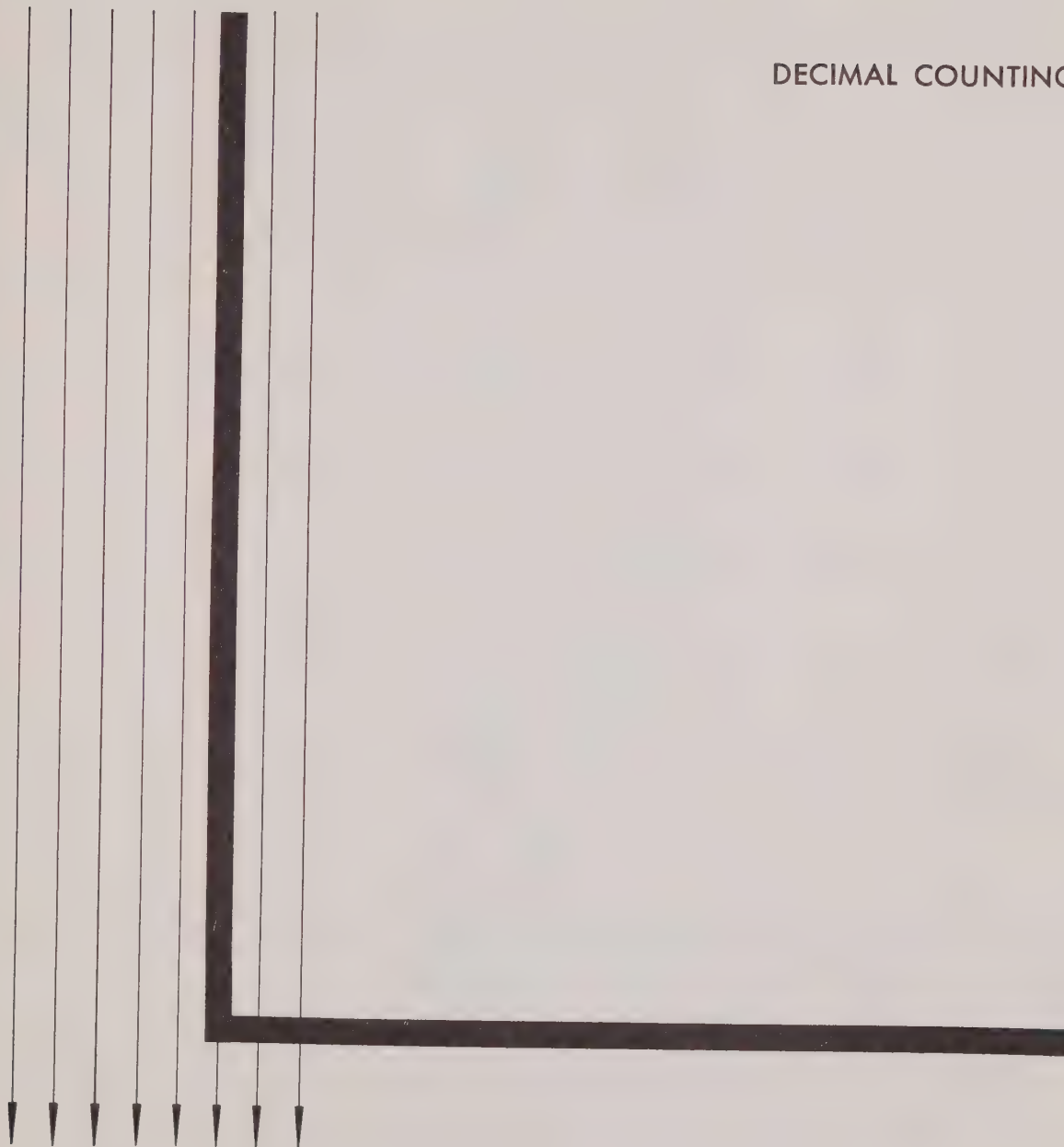
- UNLESS OTHERWISE NOTED:
RESISTORS ARE 1/2 W, 5%/a
CAPACITOR VALUES ARE IN μ f



INSTRUCTION MANUAL

Models 775, 775AJ
& 775K

DECIMAL COUNTING UNITS



Beckman®

INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

- (a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in possession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.
- (b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.
- (c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.
- (d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.
- (e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the use of the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.
- (f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.
- (g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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Appendix

Model 775R,
Dwg. No. C 402830

INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a

counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99,999 resetting to "00,000" on the 100,000th pulse.

Models 775 and 775K generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps
Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (see "OPERATION")

Output Characteristics

Designed to drive a Model 775 DCU or any modification except a 775LJ (i. e., 775AJ, 775K, etc.).

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

120,000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts a-c at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum per-

formance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 picofarads ($\mu\mu\text{f}$).

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from +135 to +55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 picofarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
775	Neg.	8	Pos.	8
775AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
775K	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 775AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3 μ seconds wide is adequate. A 100-volt pulse need be only 1.5 μ seconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 775 and 775K generate a modified binary code representing the decimal digit registered. The code appears in the

form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 775K DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 775 and 775K, it is possible to prevent the neon lamps from lighting by placing approximately +100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the lamps while the DCU is actively counting, and to allow them to light, indicating the registered count, at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

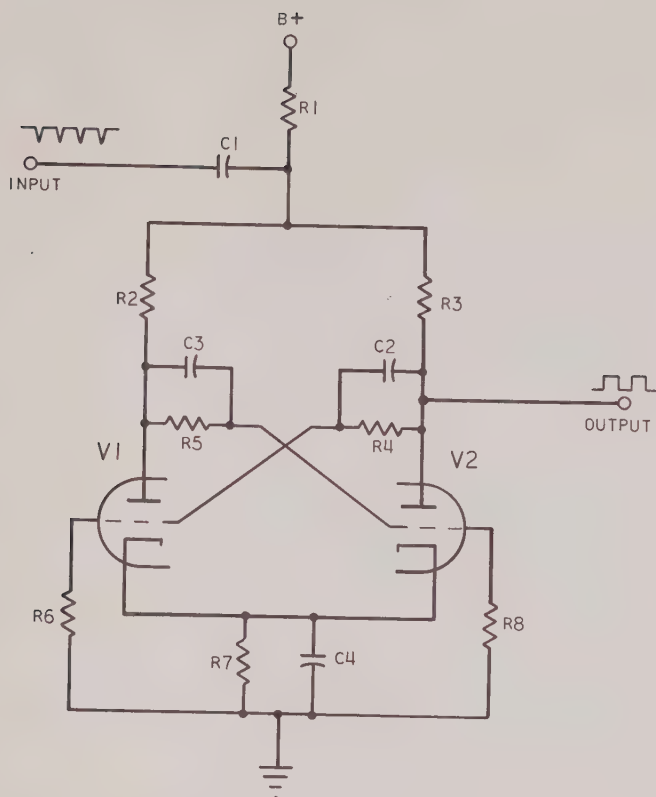


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 775 four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

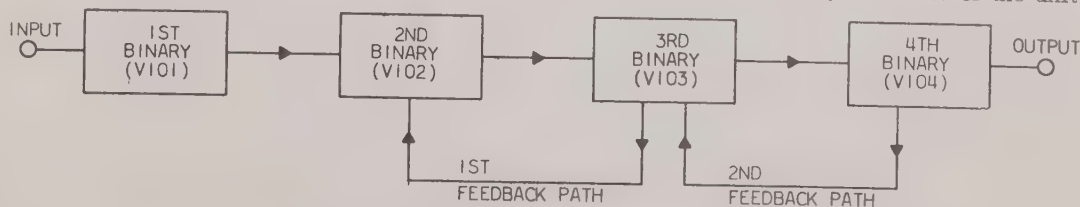


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input

pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

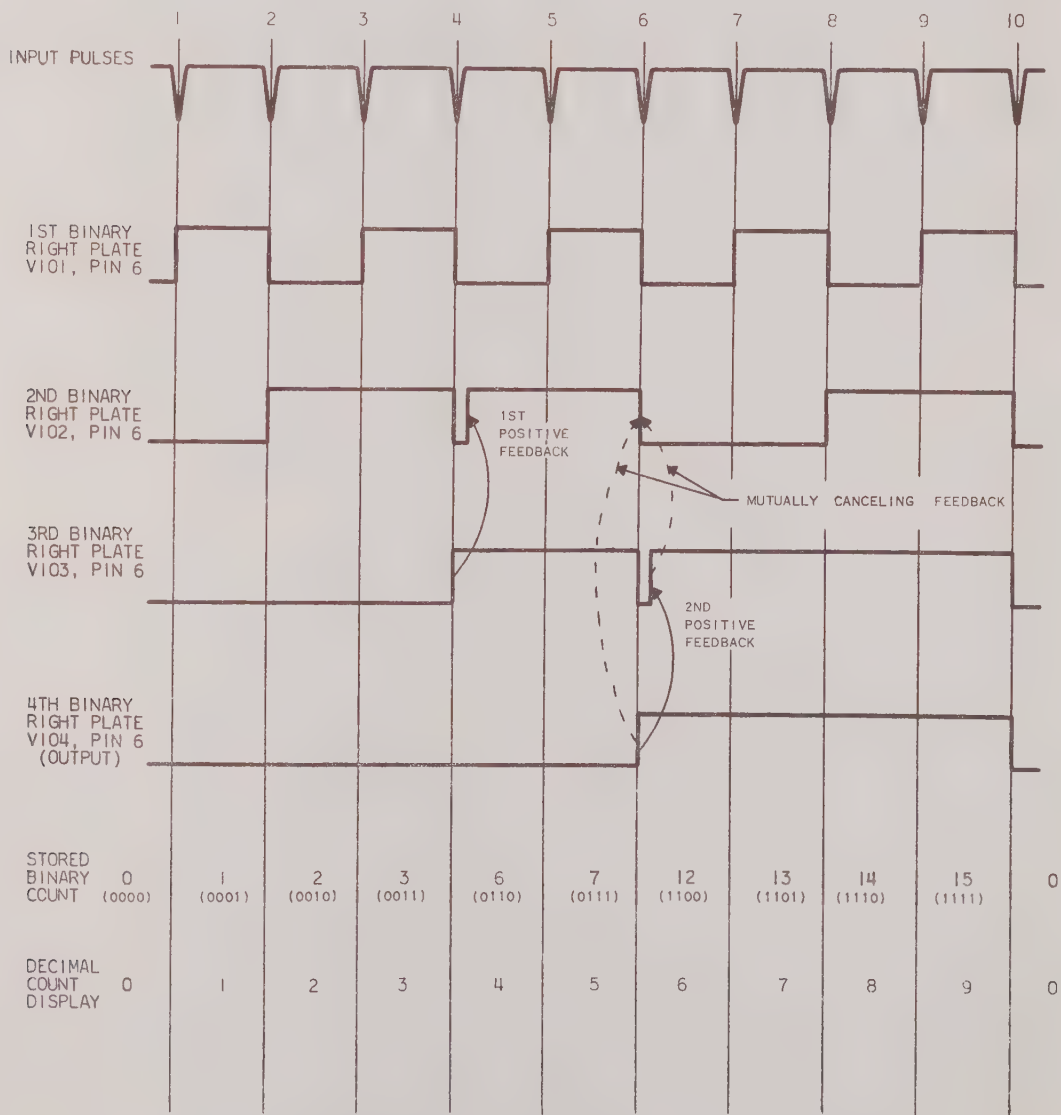


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds

and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissible tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS

POSSIBLE CAUSES

Unit Fails to Count

- (a) Insufficient supply voltage.
- (b) Input signal of insufficient amplitude
- (c) Input signal of wrong polarity.
- (d) First stage inoperative.

Unit Counts Spuriously

- (a) Extraneous input signals.
- (b) Pulses received through power supply.
- (c) External voltages picked up by output lead.

Unit Counts Erratically

- (a) Input signal too large or small, incorrect rise time.
- (b) Supply voltage fluctuating too much.

Unit Fails to Reset

- (a) Stray counts from reset switch or associated circuitry.
- (b) Defective component.

Unit counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1. Unit skips every other number
 - (a) First stage defective.
 - (b) Input circuit supplies double pulses.
2. Two stable states per cycle.
 - (a) Second stage defective (Display sequence may be 01 or 45).
 - (b) Loss of drive to second stage (01).
3. Four stable states per cycle.
 - (a) Third stage defective (Display sequence may be 0123 or 6789).
 - (b) Loss of drive to third stage (0123).
4. Six stable states per cycle.
 - (a) Output excessively loaded (Display sequence may be 012345).
 - (b) Last stage inoperative (Display sequence may be 1 012345 or 67⁸⁹₂₃89*).
 - (c) Loss of drive to fourth stage (Display sequence may be 012345).
5. Eight stable states per cycle or any failure where two successive numbers are skipped.
 - (a) Second or third stage failure.
6. Ten stable states per cycle, but the lighting sequence is incorrect.
 - (a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7. Twelve stable states per cycle.
 - (a) When lighting sequence is 0123⁰¹₄₅456789* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary.
 - (b) When the lighting sequence is 01234567²³₈₉89 the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

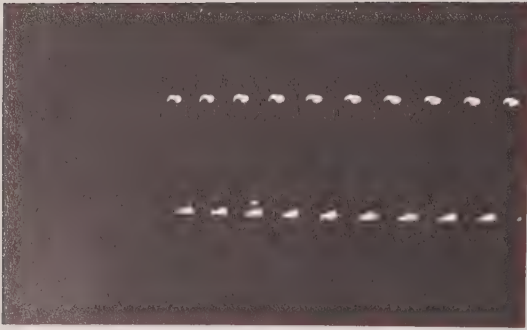
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

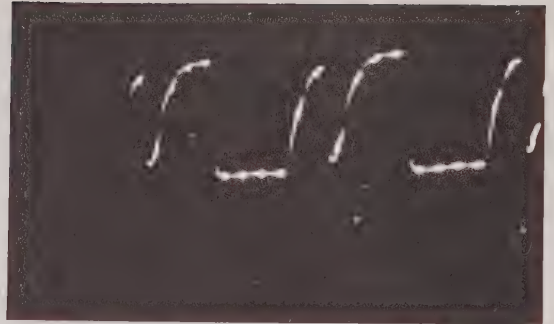
<u>Tube</u>	<u>Pin No.</u>	<u>D-C Voltage with respect to B-.*</u>	<u>Resistance to B minus Terminal**</u>
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6		105K
	7		85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6		93K
	7		83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6		100K
	7		83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6		93K
	7		83K

* Voltages measured in unit with 300-volt plate supply

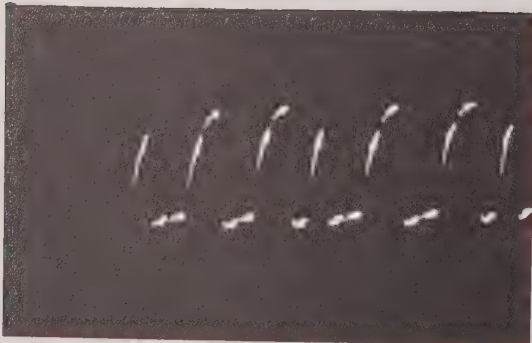
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



- ① First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



- ② Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

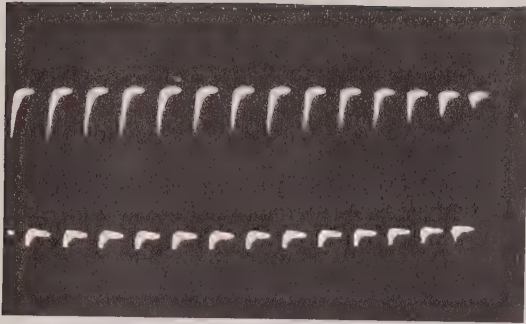


- ③ Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

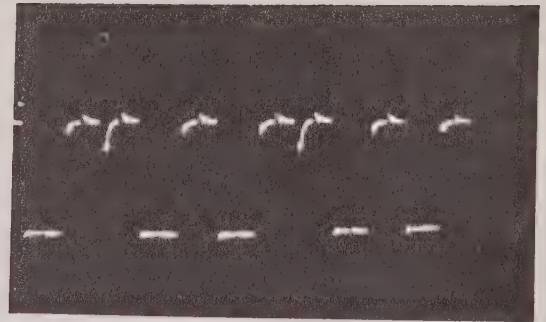


- ④ Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

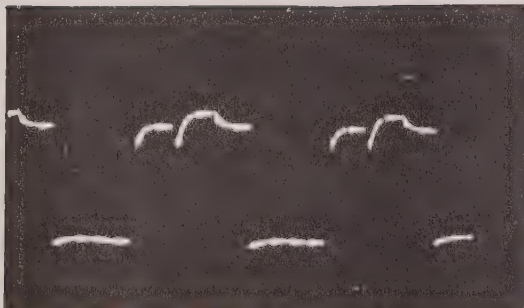
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC.
ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT
TO B MINUS.



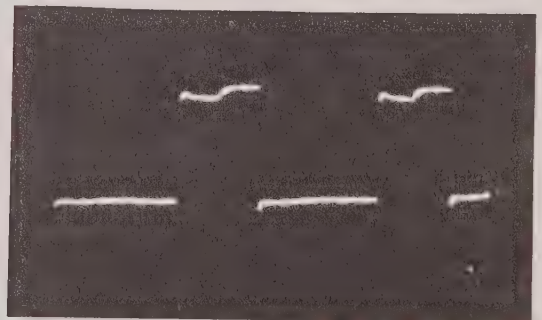
- ① First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



- ② Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



- ③ Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



- ④ Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC.
ALL VOLTAGE LEVEL'S ARE MEASURED WITH RESPECT
TO B MINUS.

COMPONENT LOCATION GUIDE

REFERENCE NO.	COMPONENT BOARD LOCATION		
	MODEL 775 FIG. 7	MODEL 775 AJ FIG. 9	MODEL 775 K FIG. 11
C101	B 17	B 17	B 17
C102	B 18	B 18	B 18
C103	C 12	C 12	C 12
C104	C 7	C 7	C 7
C105	A 19	A 19	A 19
C106	A 21	A 21	A 21
C107	A 13	A 13	A 13
C108	A 15	A 15	A 15
C109	A 8	A 8	A 8
C110	A 10	A 10	A 10
C111	A 3	A 3	A 3
C112	A 5	A 5	A 5
C113*	A 17	A 17	A 17
C114*	A 12	A 12	A 12
C115*	A 7	A 7	A 7
C116*	A 2	A 2	A 2
C117	B 8	B 8	B 8
C118	C 6	C 6	C 6
C119	B 12	B 12	B 12
C120	-	D 2	-
CR101	-	D 20	D 20
CR102	-	D 18	D 19
R101	D 21	D 21	D 21
R102	D 17	D 17	D 17
R103	D 16	D 16	D 16
R104	D 15	D 15	D 15
R105	D 14	D 14	D 14
R106	D 13	D 13	D 13
R107	D 11	D 11	D 11
R108	D 8	D 8	D 8
R109	D 6	D 6	D 6
R110	D 5	D 5	D 5
R111	D 4	D 4	D 4
R112	D 3	D 3	D 3
R113	C 19	C 19	C 19
R114	C 14	C 14	C 14
R115	C 9	C 9	C 9
R116	C 4	C 4	C 4
R117	C 20	C 20	C 20
R118	C 17	C 17	C 17
R119	C 21	C 21	C 21
R120	C 18	C 18	C 18
R121	C 16	C 16	C 16
R122	C 13	C 13	C 13
R123	C 11	C 11	C 11
R124	C 8	C 8	C 8
R125	C 5	C 5	C 5
R126	C 3	C 3	C 3
R127	A 18	A 18	A 18
R128	A 20	A 20	A 20
R129	A 14	A 14	A 14
R130	A 16	A 16	A 16
R131	A 9	A 9	A 9
R132	A 11	A 11	A 11
R133	A 4	A 4	A 4
R134	A 6	A 6	A 6
R135	B 19	B 19	B 19
R136	B 20	B 20	B 20
R137	B 14	B 14	B 14
R138	B 15	B 15	B 15
R139	B 9	B 9	B 9
R140	B 10	B 10	B 10
R141	B 4	B 4	B 4
R142	B 5	B 5	B 5
R143	A 17	A 17	A 17
R144	A 12	A 12	A 12
R145	A 7	A 7	A 7
R146	A 2	A 2	A 2
R147	B 13	B 13	B 13
R148	C 10	C 10	C 10
R149	D 2	-	-
R150	D 7	-	D 7
R151	D 12	-	D 12
R152	D 18	-	D 18
R162	B 6	B 6	B 6
R163	-	D 9	-
R164	-	D 19	-

*Reverse side of board

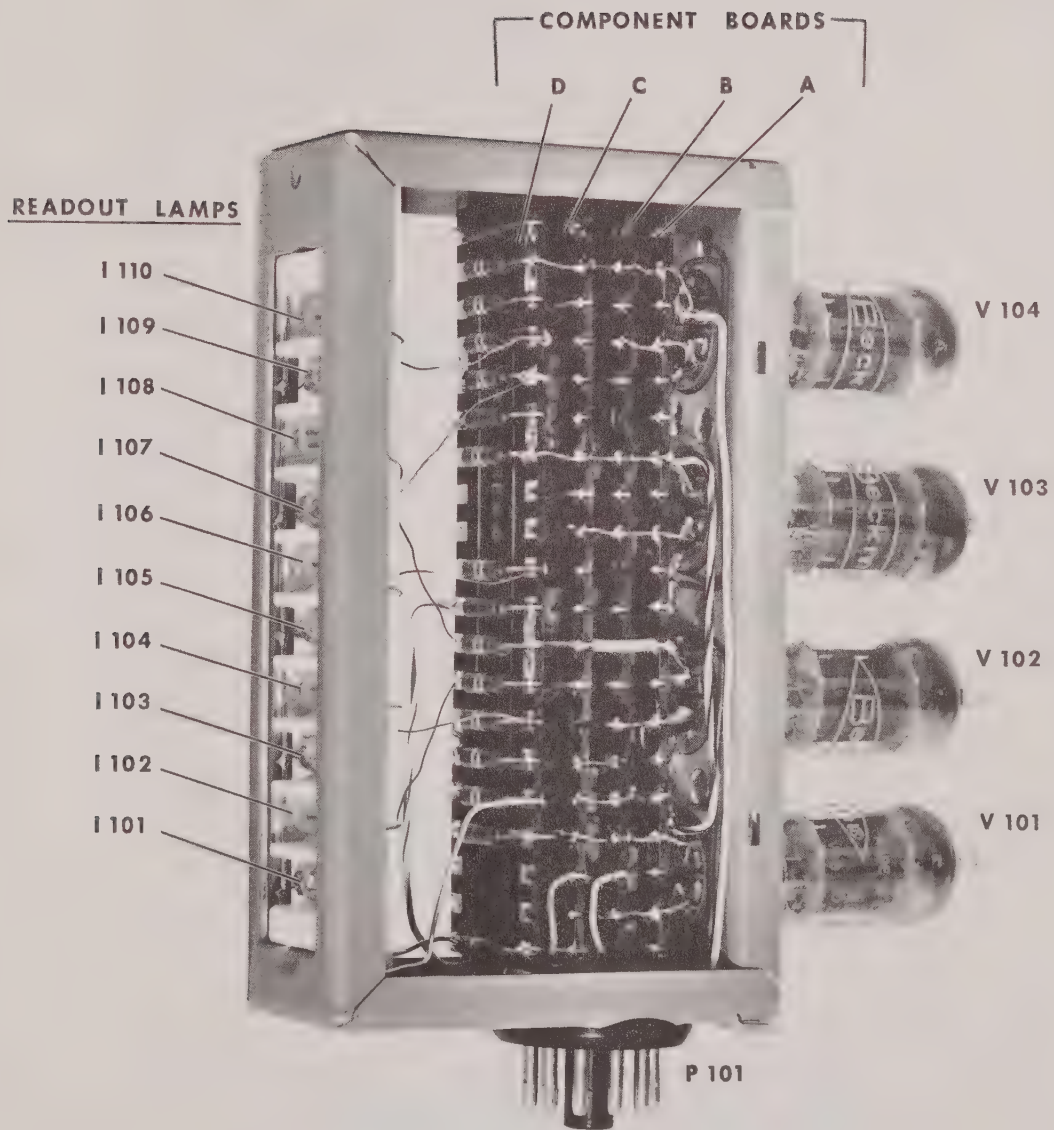


FIGURE 6. MODEL 775 DCU WITH NUMBER MASK REMOVED.

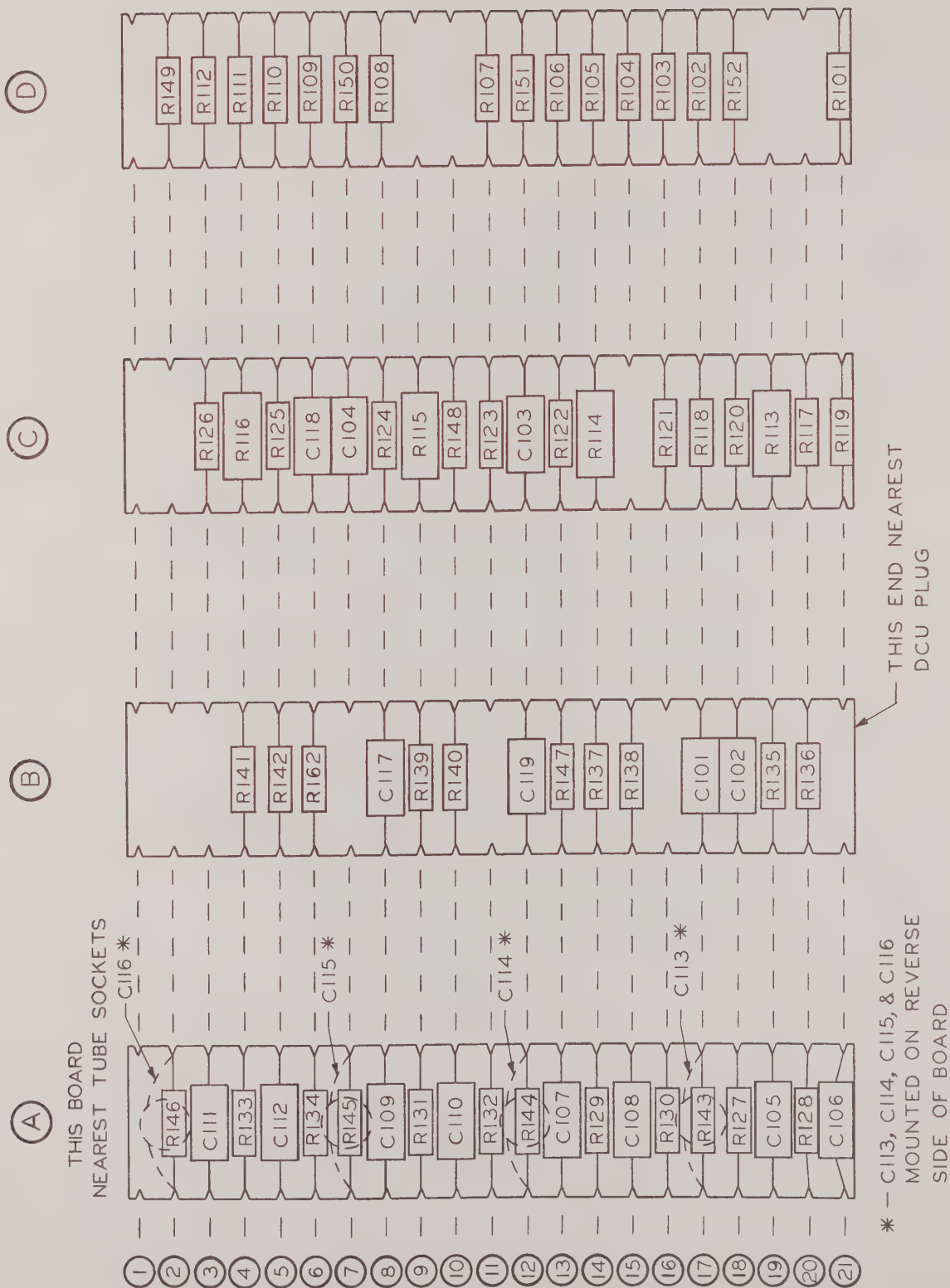


FIGURE 7. MODEL 775 COMPONENT BOARD LAYOUT.

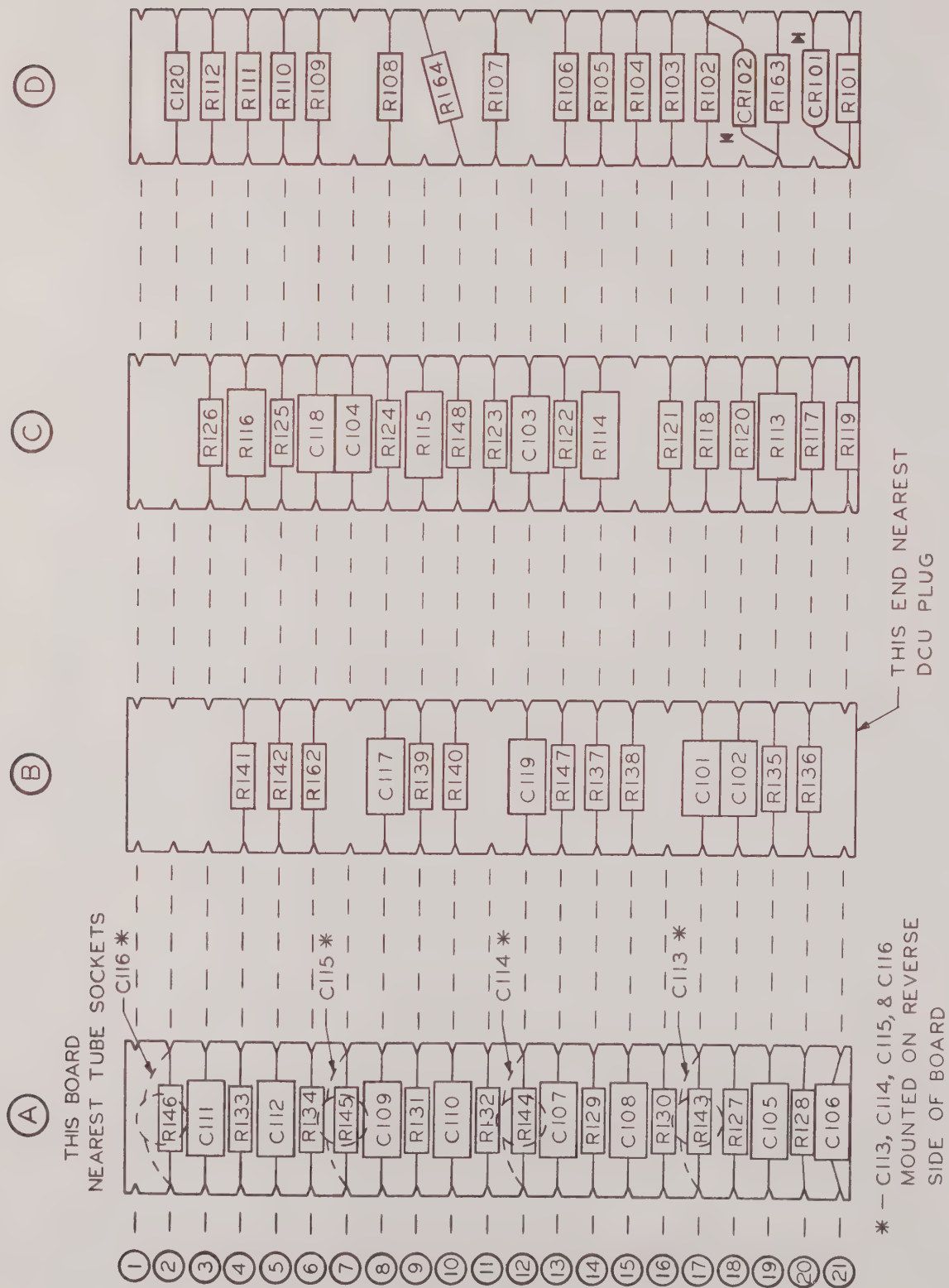


FIGURE 9. MODEL 775AJ COMPONENT BOARD LAYOUT.

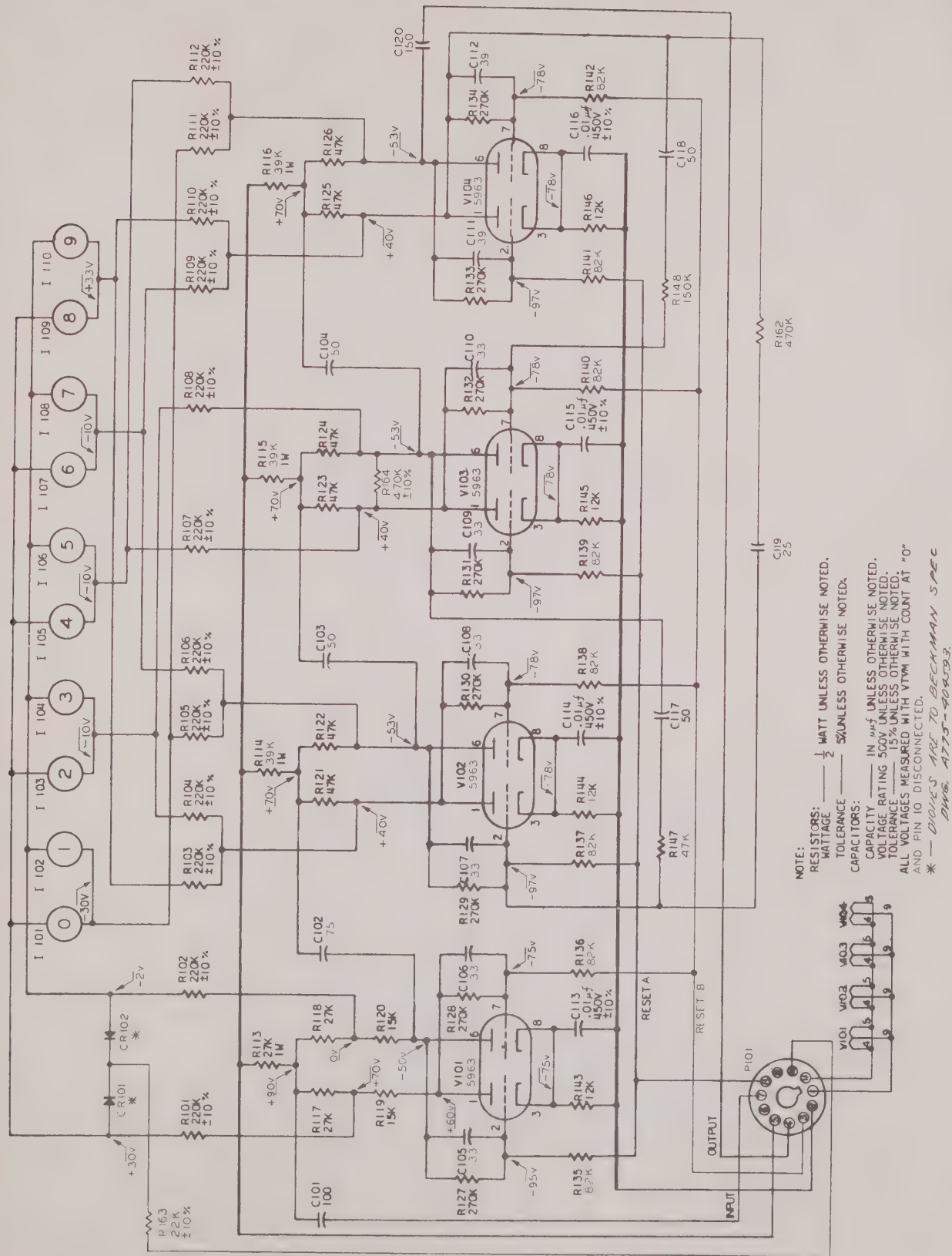


FIGURE 10. MODEL 775AJ SCHEMATIC DIAGRAM.

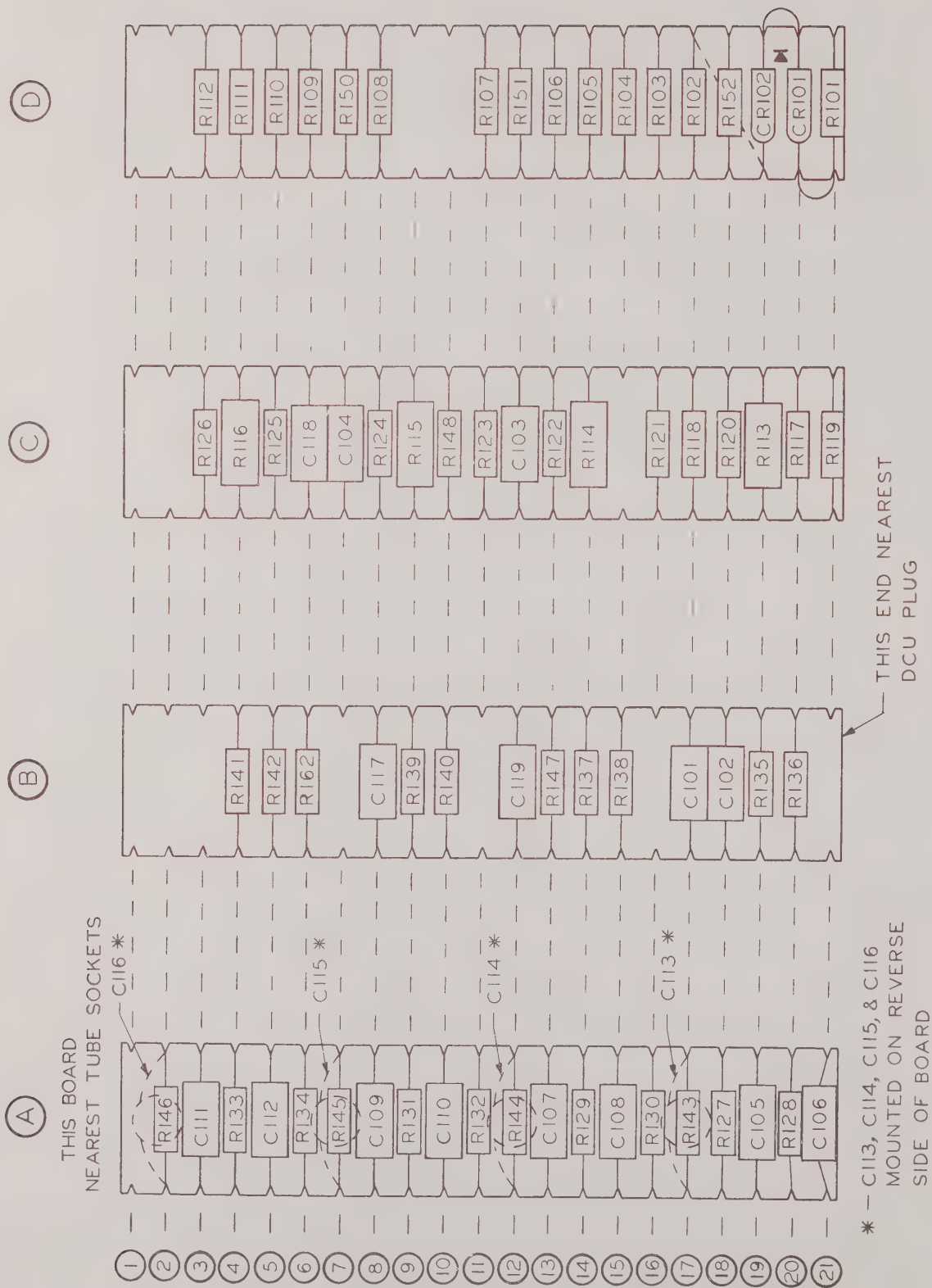


FIGURE 11. MODEL 775K COMPONENT BOARD LAYOUT.

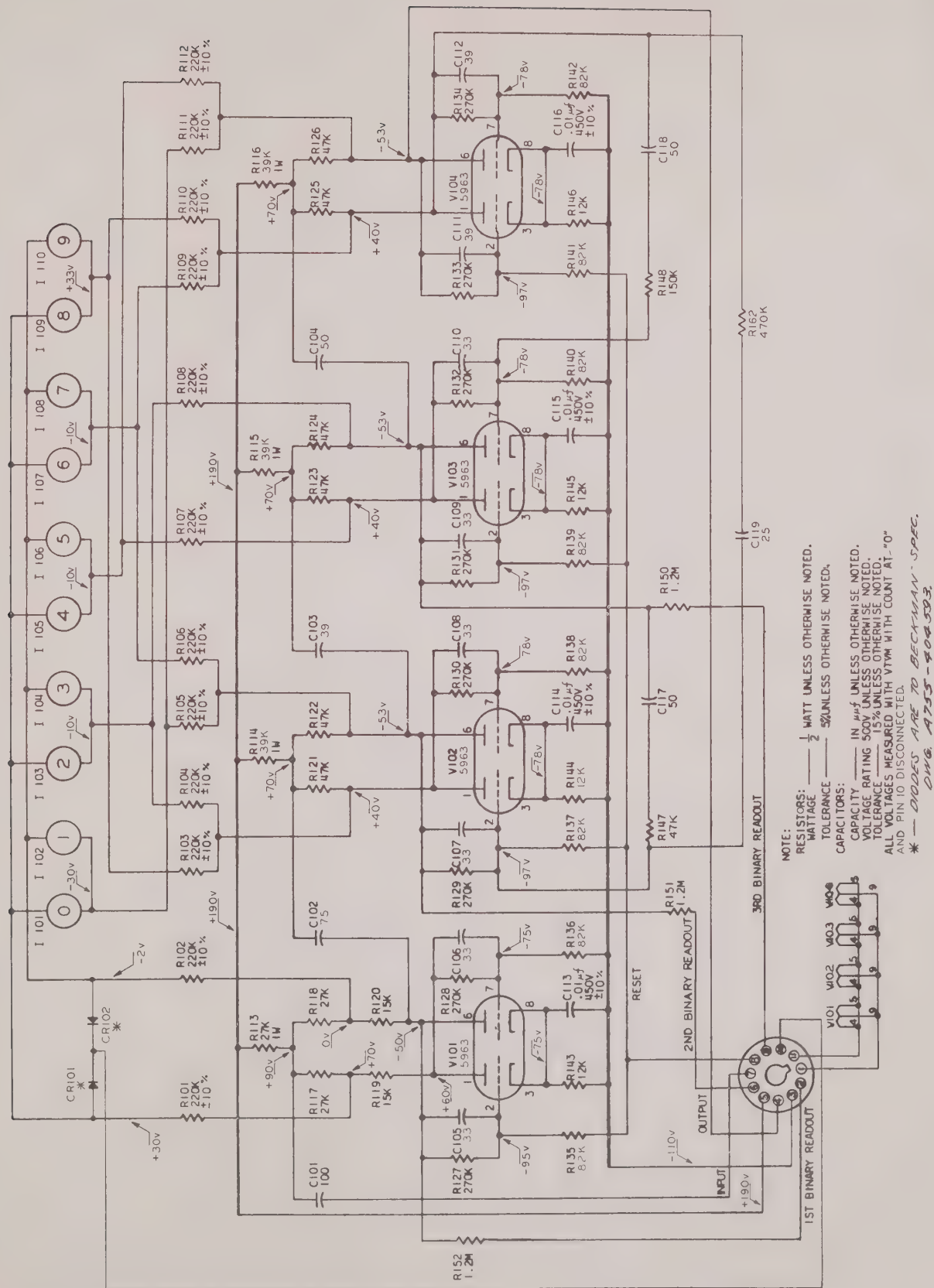
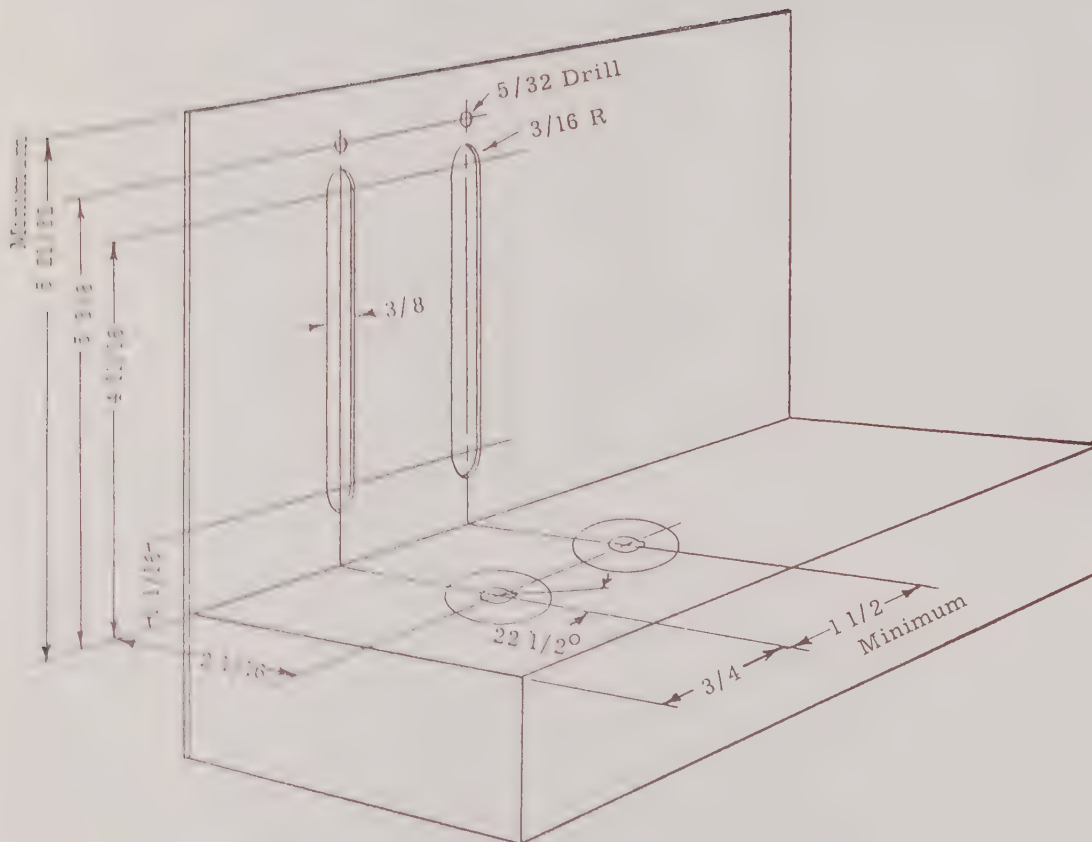


FIGURE 12. MODEL 775K SCHEMATIC DIAGRAM.



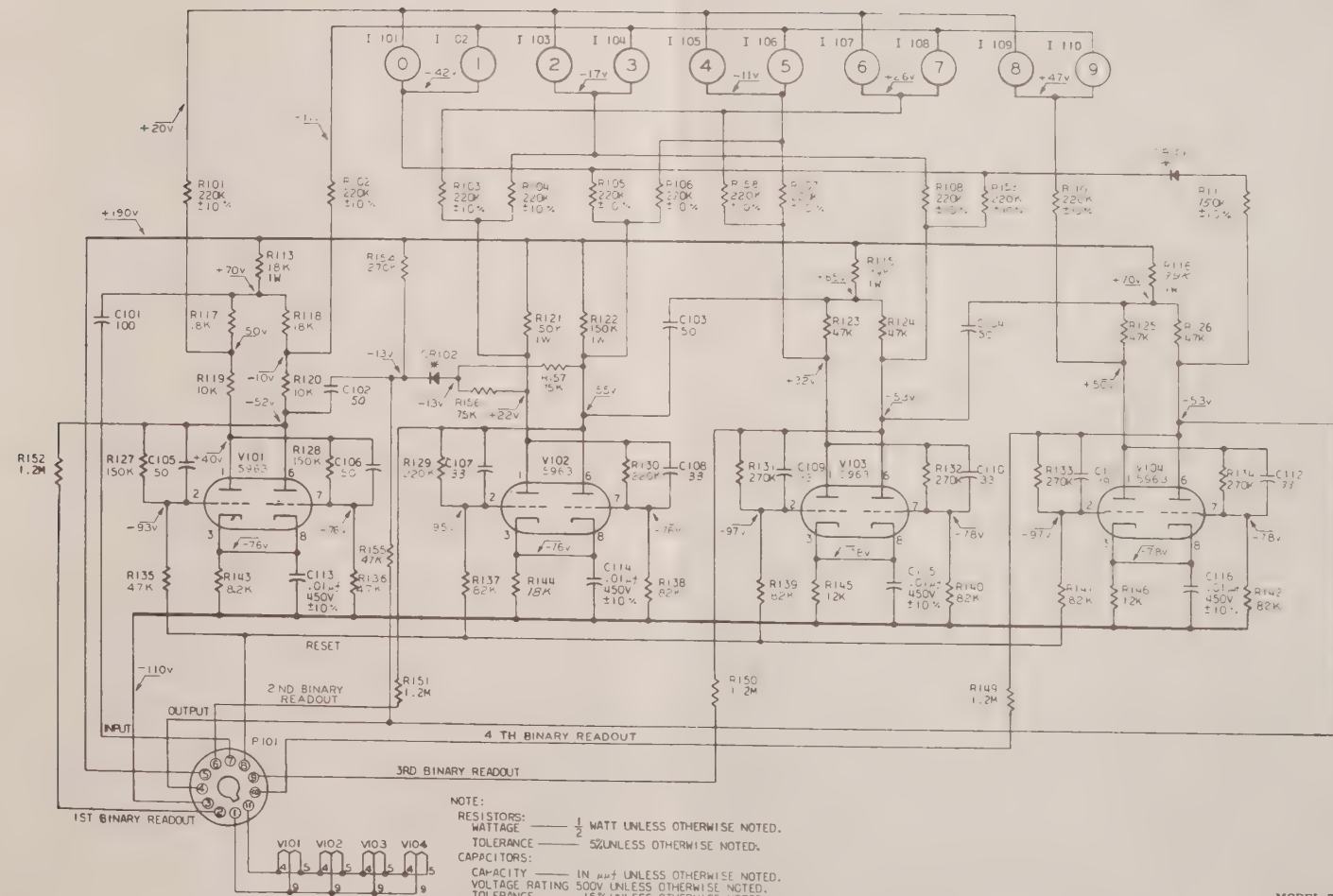
NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

FIGURE 13. MOUNTING DIMENSIONS FOR MODEL 775, 775AJ, AND 775K.

MODEL 775R
DECIMAL COUNTING UNIT

The Model 775R DCU is basically similar to the Model 775 described in this manual but has a different arrangement of readout lines to generate a 1-2-4-8 electrical readout instead of 1-2-2-4.

The schematic diagram of the Model 775R is attached.

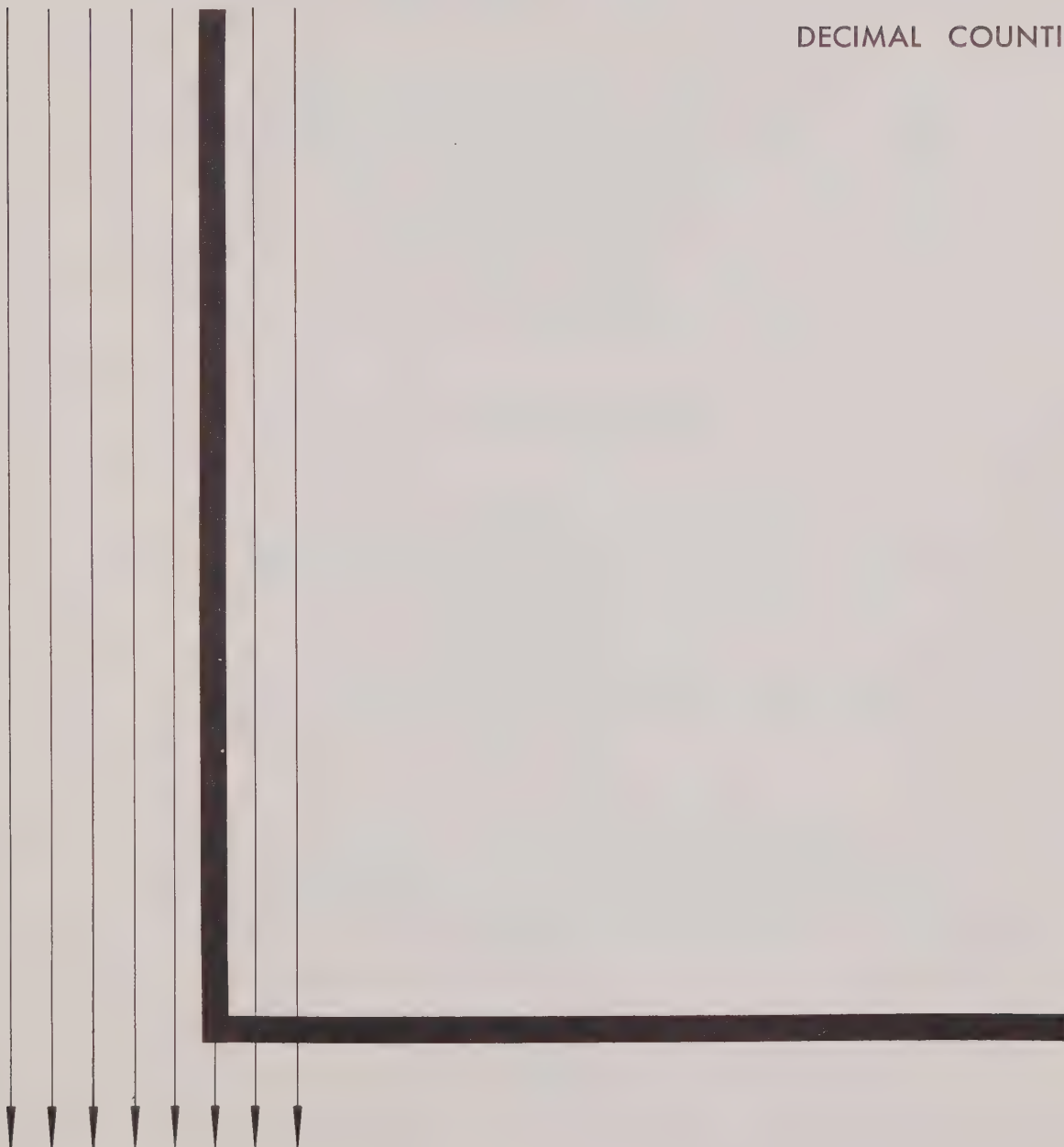


NOTE:
RESISTORS:
WATTAGE — 1/2 WATT UNLESS OTHERWISE NOTED.
TOLERANCE — 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY — IN μF UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE — 5% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
* — DIODES ARE TO BEGEMAN SPEC.
PWR. 4755-904533.

INSTRUCTION MANUAL

MODEL 785A

DECIMAL COUNTING UNIT



Beckman®

INSTRUMENTS, INC.

BERKELEY DIVISION

2200 Wright Avenue
Richmond, California

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

- (a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in possession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.
- (b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.
- (c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.
- (d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.
- (e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.
- (f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.
- (g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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Model 785A Schematic Diagram (D 402889-Rev. F)

GENERAL DESCRIPTION

The Model 785A is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 1, 100, 000 pulses per second. This output is suitable for driving a Model 775 DCU or any modification of it (775AJ, 775K, etc.) except

a 775LJ. Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of one 785A followed by five 775's will count to 999, 999, returning to "000, 000" on the 1, 000, 000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "OPERATION")

Resolution of Paired Pulses

0.8 microseconds

Maximum Counting Rate

1, 100, 000 counts per second

Output Characteristics

Designed to drive a Model 775 DCU or any modification of it except a 775LJ. (See "OPERATION".)

NOTE: The 785A will also drive the 705 series DCU's since the latter are interchangeable with the 775 series.

Reset

Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements

Heaters: 6.3V a-c at 1.8 amps near ground potential.

Plates

175 to 260 volts. (Design center is 210 volts at 45 ma.)

Construction

Plug-in unit which fits into standard 11-pin tube socket.

Dimensions

1-3/8" by 5" by 5-3/8"

Weight

1 pound

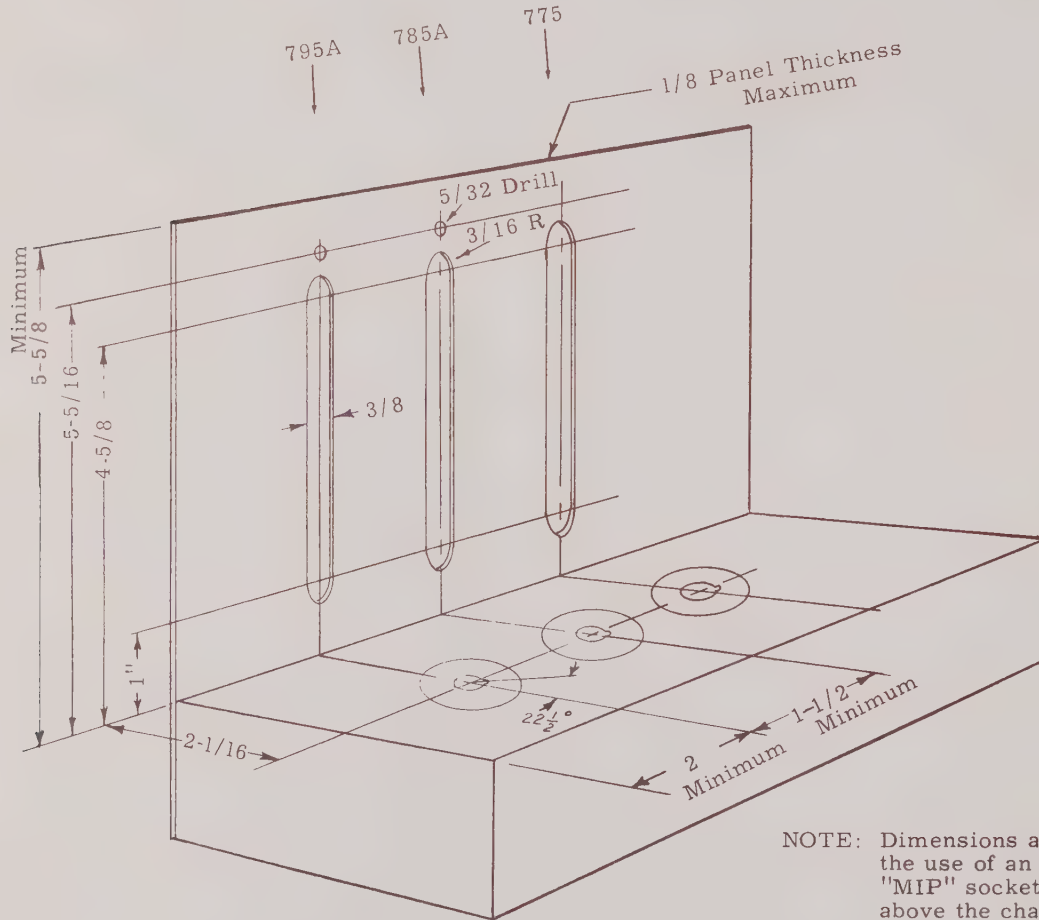
Tube Complement

Four type 12AV7.

INSTALLATION AND OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 795A (10MC) and a Model 775 (100KC).



The drawing shows the chassis dimensions for mounting Models 795A, 785A, and 775 DCU's side by side. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785A
OR 795A DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 7 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

OUTPUT CHARACTERISTICS

The output is a rectangular waveform as shown in Figure 4. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 115 volts; during count display "4" thru "9", 205 volts. Ordinarily, the 90-volt negative transient produced at the count of ten drives the following decimal counting unit.

The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 μf capacitor to ground.

METHOD OF RESET

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY CODE READOUT

The output at pins 2, 6, 9, and 10 of the DCU plug may be used to operate another binary coded readout or printing device. Refer to the Binary Readout Code table on page 6 to learn the relationship between binary digits and plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 785A DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting; then its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cutoff and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cutoff. Since small changes in the potential at the grid

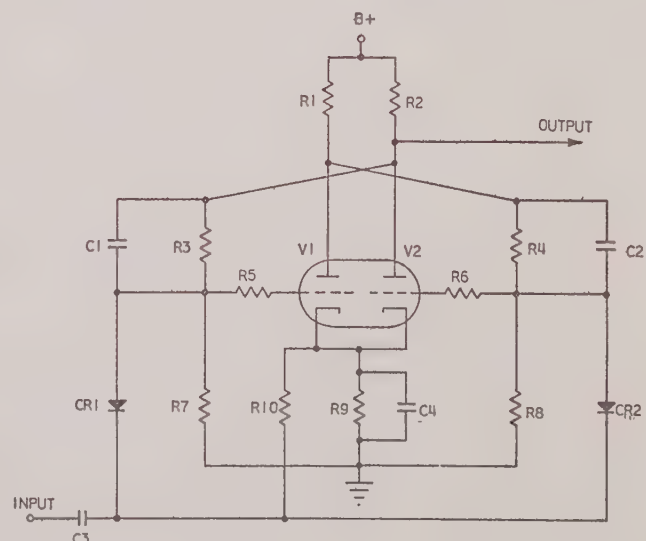


FIGURE 2.
A TYPICAL BINARY STAGE

of V1 will not raise it above cutoff, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative transients applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cutoff. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for

every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 785A three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

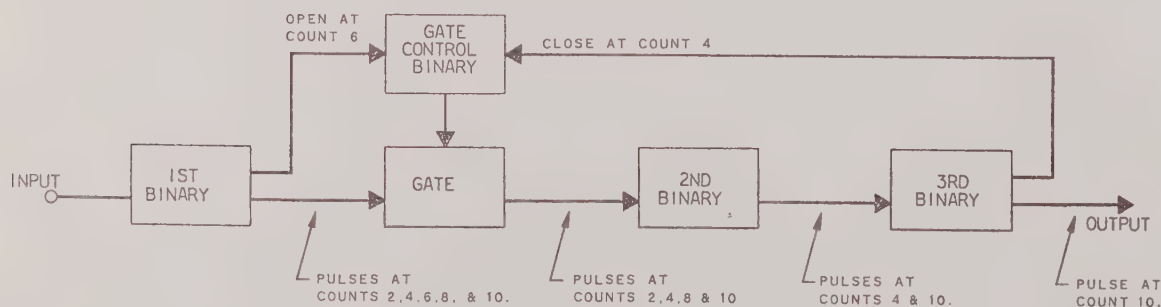


FIGURE 3.
BLOCK DIAGRAM OF MODEL 785A DCU

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts "1" through "3") the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9, and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

The operating sequence of the DCU is summarized in Table 1 which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off.

TABLE 1

Count Display	State of Each Binary Stage			
	4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

Figure 4 shows how voltages throughout the unit change as successive input pulses are received. Voltages are identified by circled reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself.

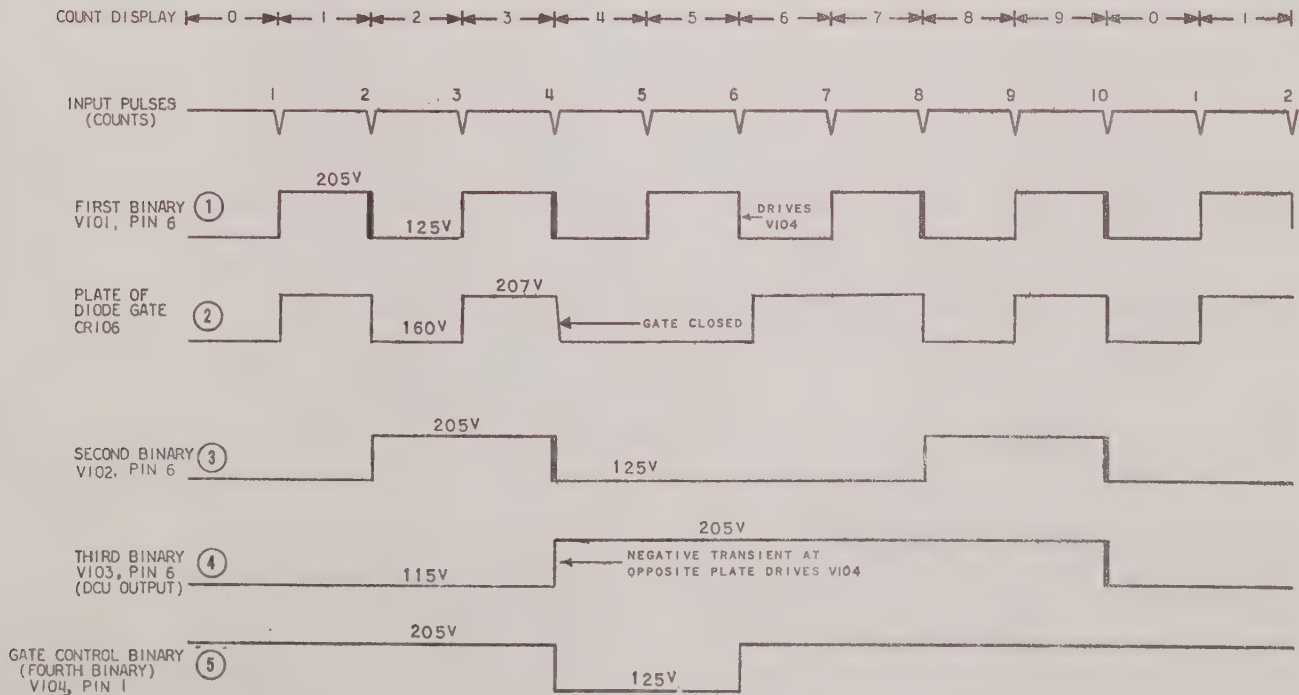


FIGURE 4.

IDEALIZED WAVEFORMS

The waveforms at this junction are identical to the plate waveforms shown in Figure 4, but of smaller amplitude. The negative transients (shown in heavy lines in Figure 4) drive succeeding binaries. The negative transient from the first binary which occurs at count 6 does not reach the second binary because of the action of the gate diode CR106 described in the paragraph "Gate Control Circuit".

Actual oscilloscope waveforms are shown in Figure 8. Each photograph has a number corresponding to the point on the schematic diagram where the waveform was observed.

BINARY CODE READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of the right half of the fourth binary while the voltage at pin 10 combines the output of the third binary with that of the left half of the fourth binary. The resultant modified binary code given in Table 2 below agrees with that generated by other Beckman instruments. In the table, "0" represents a voltage of -15 volts or more negative; "1" represents a voltage at ground level or more positive.

TABLE 2. BINARY READOUT CODE

Count Display	Pin on DCU Plug			
	<u>10</u>	<u>9</u>	<u>6</u>	<u>2</u>
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

GATE CONTROL CIRCUIT

At count 4, the voltage at the right plate of the third binary (Point ④ on the schematic) rises. At the same time, the voltage at the left plate drops. The negative transient produced at the left plate is coupled to the right grid of the gate control binary (V104), causing it to switch to the state in which the left triode conducts. (Point ⑤). The resultant voltage drop across R119 causes the plate of the diode gate (CR106) to drop to +160v. (Point ②). At this time the diode plate voltage is equal to its cathode voltage, which varies between +207v and +160v. The diode does not conduct and therefore prevents the negative output transient at count 6 from reaching the second binary. However, the negative output pulse of V101 is coupled through C104 to the left grid of the control binary which is now above cutoff. This switches the control binary back to its original stable state, opening the gate to pass a trigger pulse to the second binary at count 8.

OUTPUT CIRCUITRY

As the DCU cycles through counts "1" to "10", ten discrete combinations of binary states are produced, corresponding to the binary code given in the table on the preceding page. The output voltage of binaries #2 through #4 is at one of two levels which we shall designate "high" or "low". The outputs are connected to the neon bulbs in a matrix using diodes so that if one lamp terminal is connected to a low potential the voltage at that point will remain low regardless of the output level of another binary which may be connected to the same terminal. The output voltage of binary #1 is either "low" or "intermediate" because the voltage divider networks in the plate circuits prevent the voltage from reaching the "high" level.

At count "1" lamp No. 1 has both high and low potentials existing at its terminals. The circuit can be analyzed as in Figure 5 for each count of the cycle in order to verify that this condition will exist for only one neon bulb at each count.

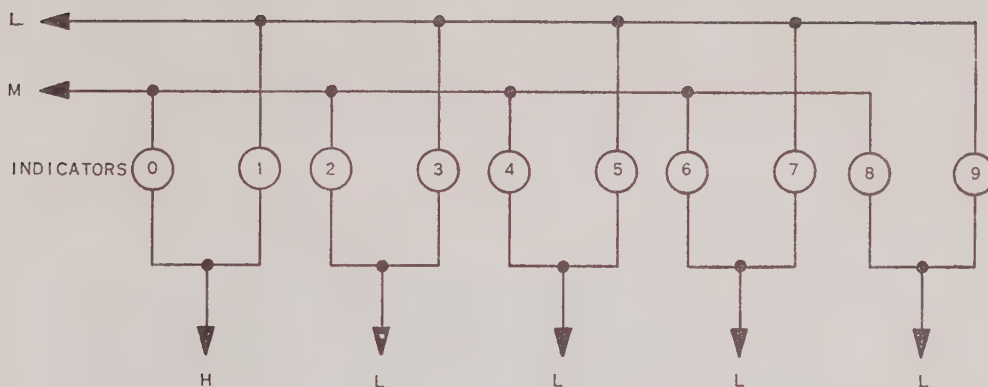


FIGURE 5.
VOLTAGE LEVELS ACROSS NEON BULBS EXISTING AT COUNT ONE
(H = HIGH, M = INTERMEDIATE, L = LOW)

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method

should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart (Table 3) lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. Voltage and resistance measurements at tube pins are given in Table 5.

It will be found that most failures are caused by faulty tubes.

TABLE 3

TROUBLESHOOTING CHART

NOTE: Reset unit before troubleshooting

<u>Symptom</u>	<u>Cause</u>	<u>Symptom</u>	<u>Cause</u>
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative	Unit counts in wrong sequence	
		1. Skips every other number	(a) First stage defective (b) Input circuit supplies double pulses
		2. Skips 4 and 5	(a) 4th stage not being driven by the 3rd
		3. Skips 6 and 7	(a) Defective gate diode (CR106)
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead	Repeats a pattern of numbers	
		1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd stage not being driven
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much	2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd stage not being driven
		3. Counts up to 5, then alternates between 4-5	(a) 4th stage not being driven by the 1st
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component	Two lamps light simultaneously	Defective diode (CR101 to CR105)

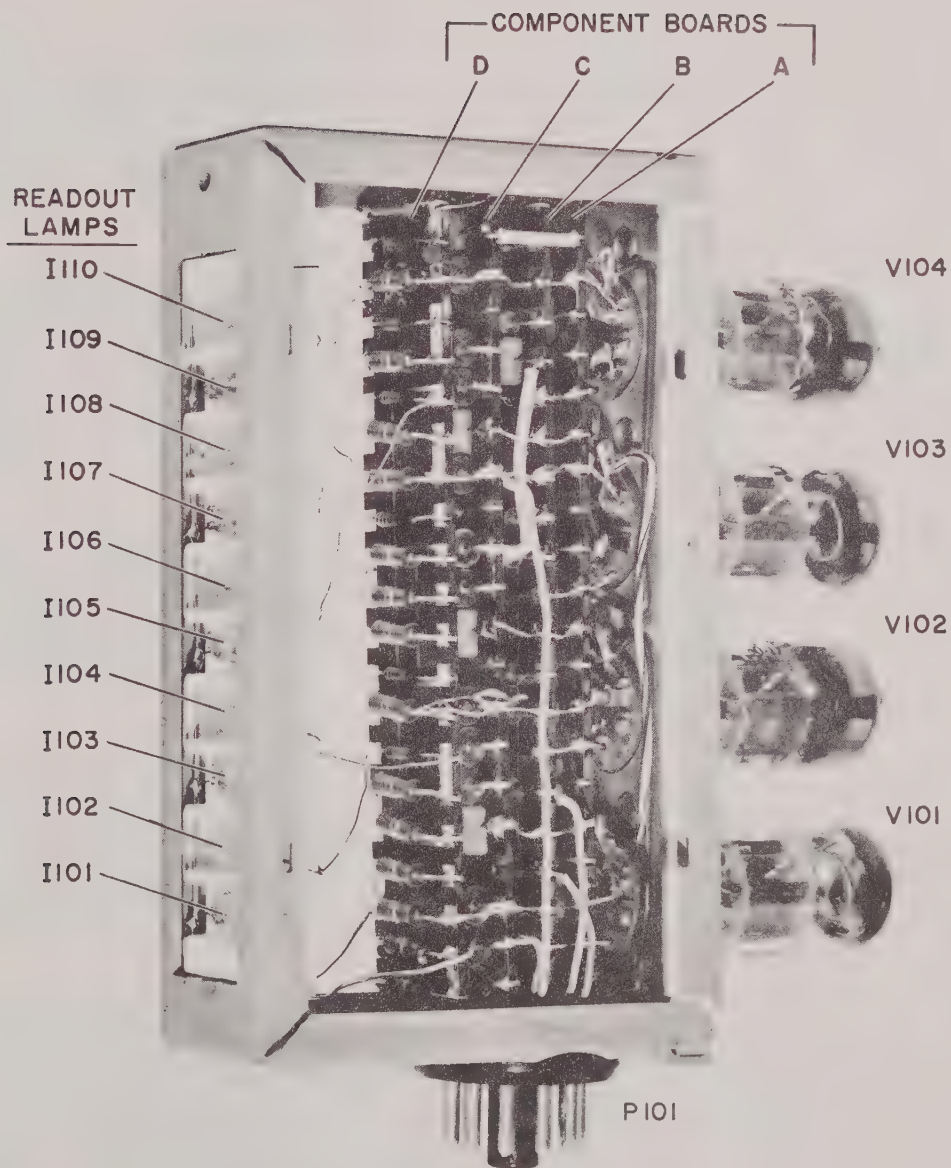


FIGURE 6.
MODEL 785A DCU WITH NUMBER MASK REMOVED

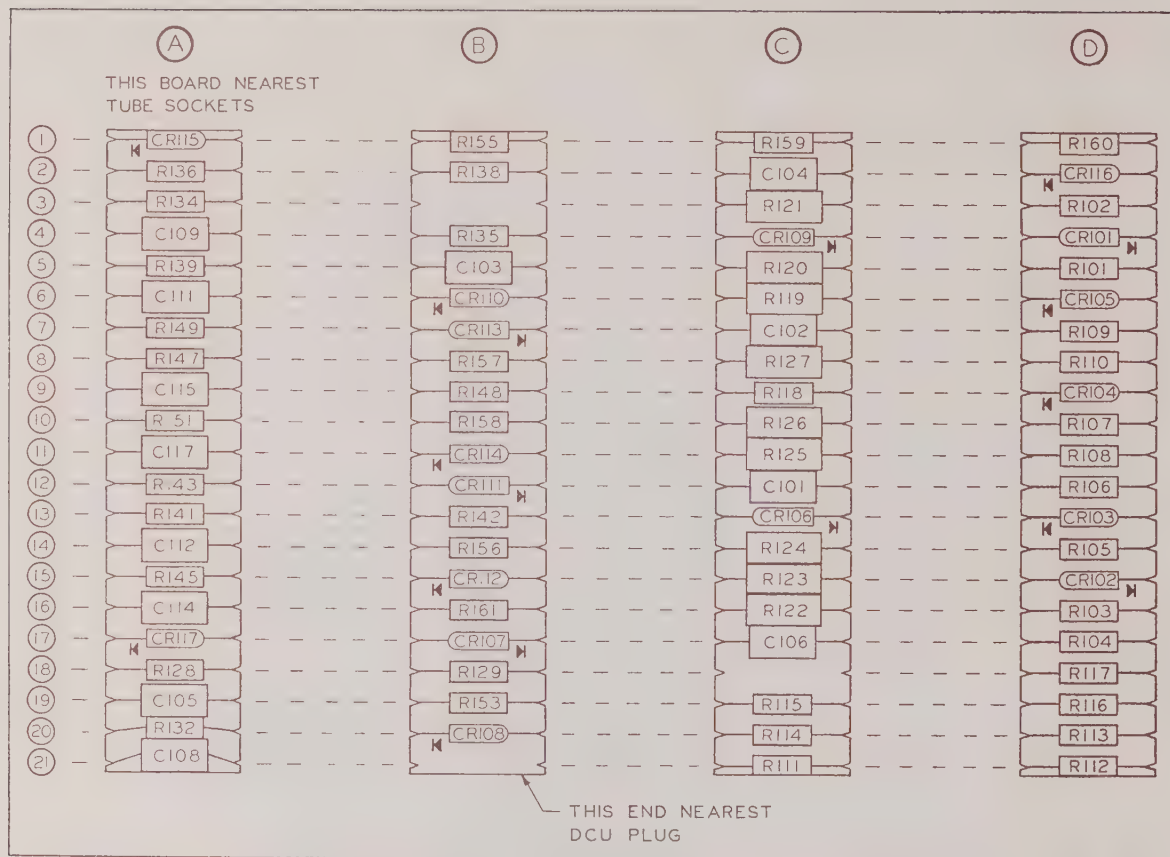
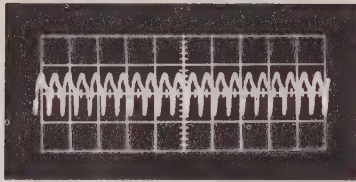


FIGURE 7.
COMPONENT BOARD LAYOUT

TABLE 4. PARTS LOCATION GUIDE*

Reference Number	Position (Fig. 7)	Reference Number	Position (Fig. 7)	Reference Number	Position (Fig. 7)
C101	C 12	CR115	A 1	R125	C 11
C102	C 7	CR116	D 2	R126	C 10
C103	B 5	CR117	A 17	R127	C 8
C104	C 2			R128	A 18
C105	A 19	R101	D 5	R129	B 18
C106	C 17	R102	D 3	R132	A 20
C108	A 21	R103	D 16	R134	A 3
C109	A 4	R104	D 17	R135	B 4
C111	A 6	R105	D 14	R136	A 2
C112	A 14	R106	D 12	R138	B 2
C114	A 16	R107	D 10	R139	A 5
C115	A 9	R108	D 11	R141	A 13
C117	A 11	R109	D 7	R142	B 13
		R110	D 8	R143	A 12
CR101	D 4	R111	C 21	R145	A 15
CR102	D 15	R112	D 21	R147	A 8
CR103	D 13	R113	D 20	R148	B 9
CR104	D 9	R114	C 20	R149	A 7
CR105	D 6	R115	C 19	R151	A 10
CR106	C 13	R116	D 19	R153	B 19
CR107	B 17	R117	D 18	R155	B 1
CR108	B 20	R118	C 9	R156	B 14
CR109	C 4	R119	C 6	R157	B 8
CR110	B 6	R120	C 5	R158	B 10
CR111	B 12	R121	C 3	R159	C 1
CR112	B 15	R122	C 16	R160	D 1
CR113	B 7	R123	C 15	R161	B 16
CR114	B 11	R124	C 14		

*Parts not listed in this table can be found at the appropriate tube socket terminals.

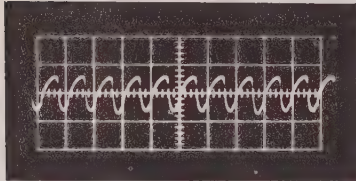


INPUT PULSES

Test Point: P101, pin 7

Vert. Scale: 5v/div

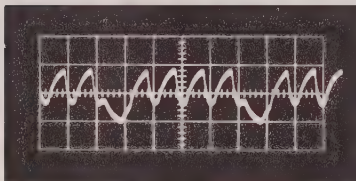
Note: The pulses shown are the output of a 10 mc DCU.



FIRST BINARY, PLATE B

Test Point: V101, pin 6

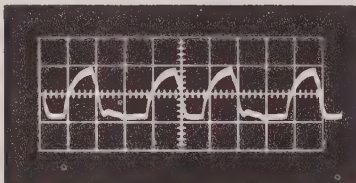
Vert. Scale: 50v/div



GATE DIODE (CR106), ANODE

Test Point: Junction CR106, C101, R118

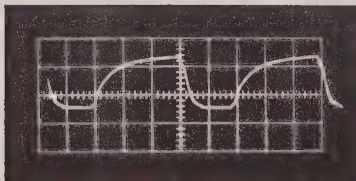
Vert. Scale: 50v/div



SECOND BINARY, PLATE B

Test Point: V102, pin 6

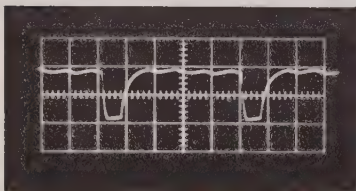
Vert. Scale: 50v/div



THIRD BINARY, PLATE B

Test Point: V103, pin 6

Vert. Scale: 50v/div



FOURTH (GATE CONTROL) BINARY, PLATE A

Test Point: V104, pin 1

Vert. Scale: 50 v/div

FIGURE 8

TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 1 MC.

TIME SCALE IS $2\mu\text{s}/\text{DIV}$

TABLE 5a

VOLTAGES

Note: Voltages measured to ground at count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 200 volts.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	+170	+42	+56	0	0	+104	+56	+56	6.3AC
V102	+170	+38	+52	0	0	+94	+52	+52	6.3AC
V103	+170	+19	+32	0	0	+78	+33	+32	6.3AC
V104	+170	+37	+50	0	0	+92	+53	+50	6.3AC

TABLE 5b

RESISTANCES

Note: Resistances are measured to chassis ground with the DCU removed from its socket.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	23K	33K	7K	∞	∞	25K	26K	7K	∞
V102	26K	18K	5.8K	∞	∞	26K	15K	5.8K	∞
V103	25K	11K	3.4K	∞	∞	24K	11K	3.4K	∞
V104	26K	21K	6K	∞	∞	26K	17K	6K	∞

PARTS LIST MODEL 785A DECIMAL COUNTING UNIT

Refer to Dwg. No. D 402889

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.	Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C101	2-2607	Capacitor, mica, 33µuf, 500V, 5%	Sangamo RR1433	CR106	8-7453	Diode, 1N827	
C102	2-2554	Capacitor, mica, 24µuf, 500V, 5%	Sangamo DR1424	CR107		Same as CR101	
C103	2-3157	Capacitor, mica, 39µuf, 500V, 5%	Sangamo RR1439	CR108		thru	
C104	2-2141	Capacitor, mica, 50µuf, 500V, 5%	Sangamo RR1450	CR114		Same as CR107	
C105	2-2135	Capacitor, mica, 15µuf, 500V, 5%	Sangamo RR1415	CR115 &			
C106	2-2137	Capacitor, mica, 500µuf, 300V, 5%	Sangamo RR1350	CR116		Same as CR101	
C107	2-4388	Capacitor, ceramic, .01µf, 500V, +80 -20%	Sprague 28C9	CR117		Same as CR107	
C108 &		Same as C105		I101	21-6180	Lamp, NE23	General Electric
C109		Same as C105		I102		thru	
C110		Same as C107		I110		Same as I101	
C111 &		Same as C105		L101	3-7251	Ferrite bead	Ferroxcube 255 T 138 A 205
C112		Same as C105		L102		thru	
C113		Same as C107		L108		Same as L101	
C114		Same as C105		P101	17-1719	Plug, 11 pin	Amphenol 86CP11
C115		Same as C102		V101	3-5977	Tube, 12AV7	
C116		Same as C107		V102		thru	
C117		Same as C105		V104		Same as V101	
CR101	404593	Diode,	Beckman/Berkeley	XV101	4-3217	Socket, 9 pin	Elco 280BC
CR102		thru		XV102		thru	
CR105		Same as CR101		XV104		Same as XV101	

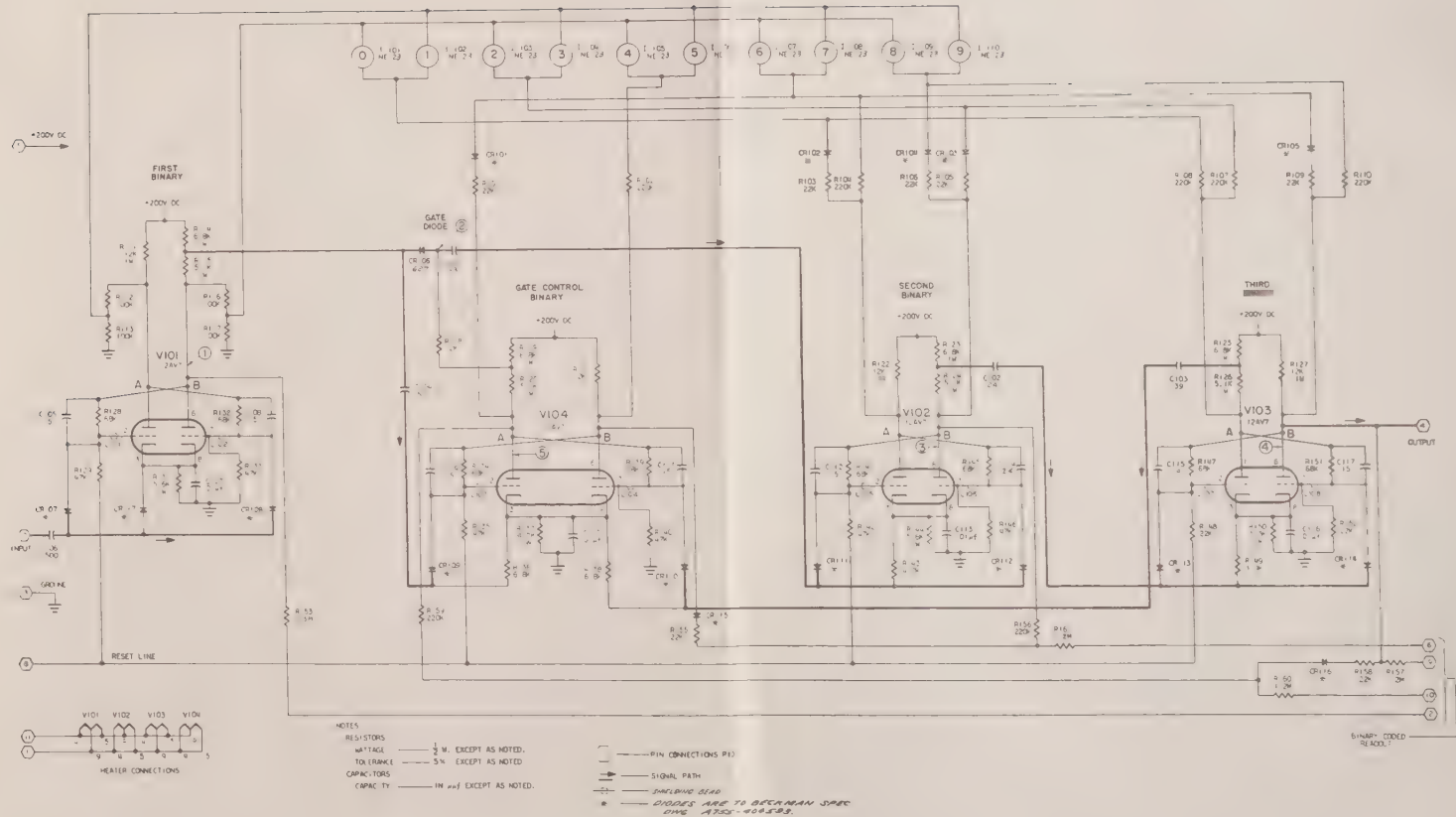
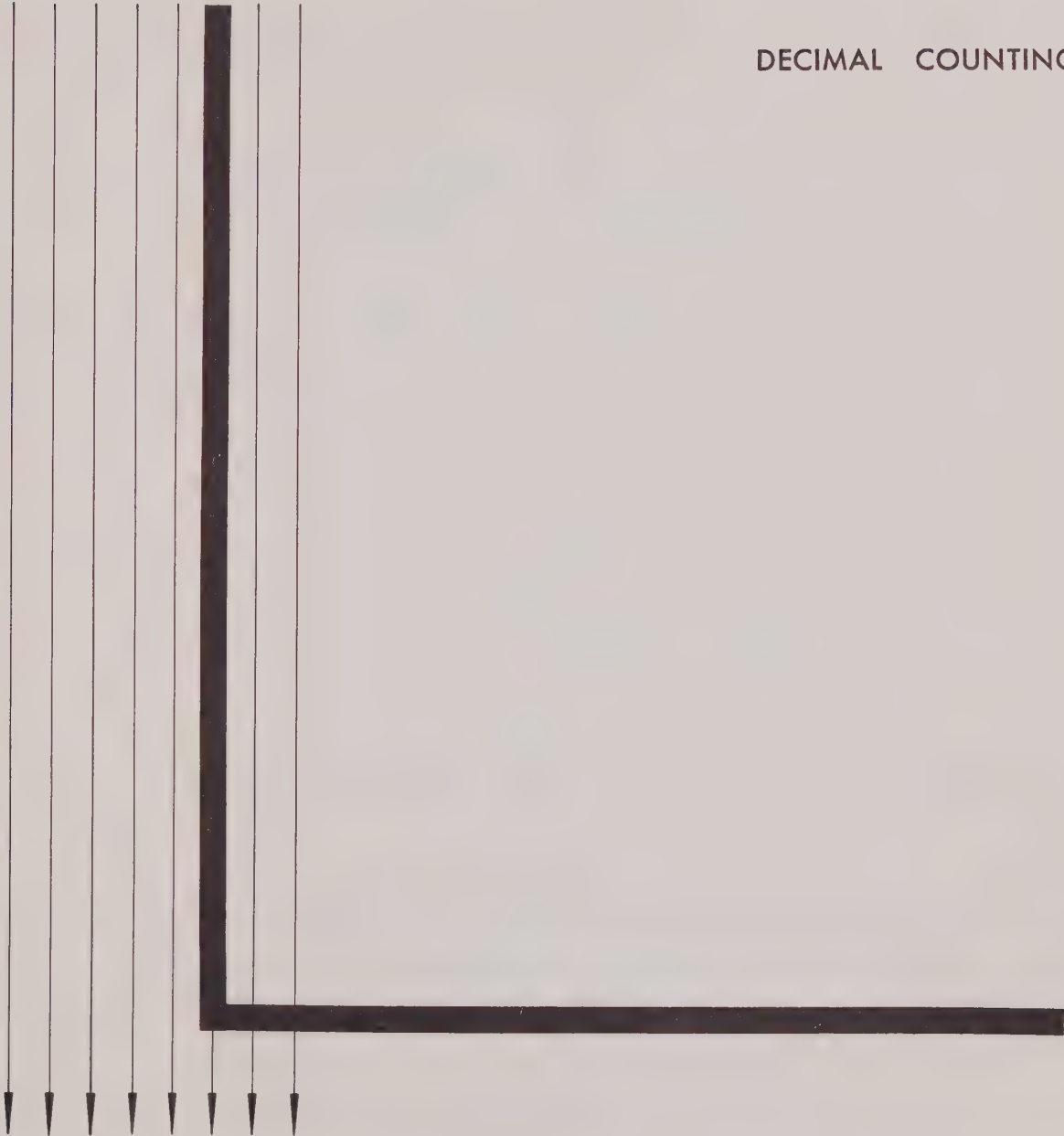


TABLE 5a

INSTRUCTION MANUAL

MODEL 795A

DECIMAL COUNTING UNIT



Beckman®

INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

- (a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in possession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.
- (b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.
- (c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.
- (d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.
- (e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.
- (f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.
- (g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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GENERAL DESCRIPTION

Model 795A Decimal Counting Unit is a direct-reading, plug-in electronic counter that registers voltage pulses applied at its input terminal. Its maximum counting rate is 11,500,000 pulses per second. During one cycle of operation it counts from one through nine, then resets to zero at the tenth input pulse, simultaneously generating an output signal. The count is displayed by the illumination of one of ten neon lamps behind a number mask.

The output is suitable for driving a 1 mc DCU (Model 785A) which will in turn drive any number of 100 kc DCU's (Model 775 series) connected in cascade (one driving the next). Thus, a chain consisting of a 795A, a 785A, and five 775's will count to 9,999,999, returning to zero on the 10,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of two voltage levels at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "INSTALLATION & OPERATION")

Resolution of Paired Pulses

0.09 μ seconds

Maximum Counting Rate

11,500,000 counts per second

Output Characteristics

Designed to drive a Model 785A DCU (See "INSTALLATION & OPERATION".)

Reset

Reset to zero by negative pulse, 50v in amplitude, 1 microsecond wide, applied to pin 8 of plug.

Power Requirements

Heater Supply: 6.3 v ac at 2.2 amps near ground potential.

B- Supply: -110 volts at 80 ma applied at pin 3.

B+ Supply: +120 volts at 15 ma applied at pin 7. (The B+ supply voltage is superimposed on the input signal.)

Construction

Plug-in unit: fits into standard 11-pin tube socket.

Dimensions

5 - 3/8 in. high by 2 - 3/8 in. wide by 5 in. deep

Weight

1 lb.

Tube Complement

5 type 6922

1 type 5964

INSTALLATION & OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

MOUNTING

Figure 1 shows the dimensions of a chassis for mounting Model 795A, 785A and 775 DCU's side by side. Spacing between all units (or additional units) is identical.

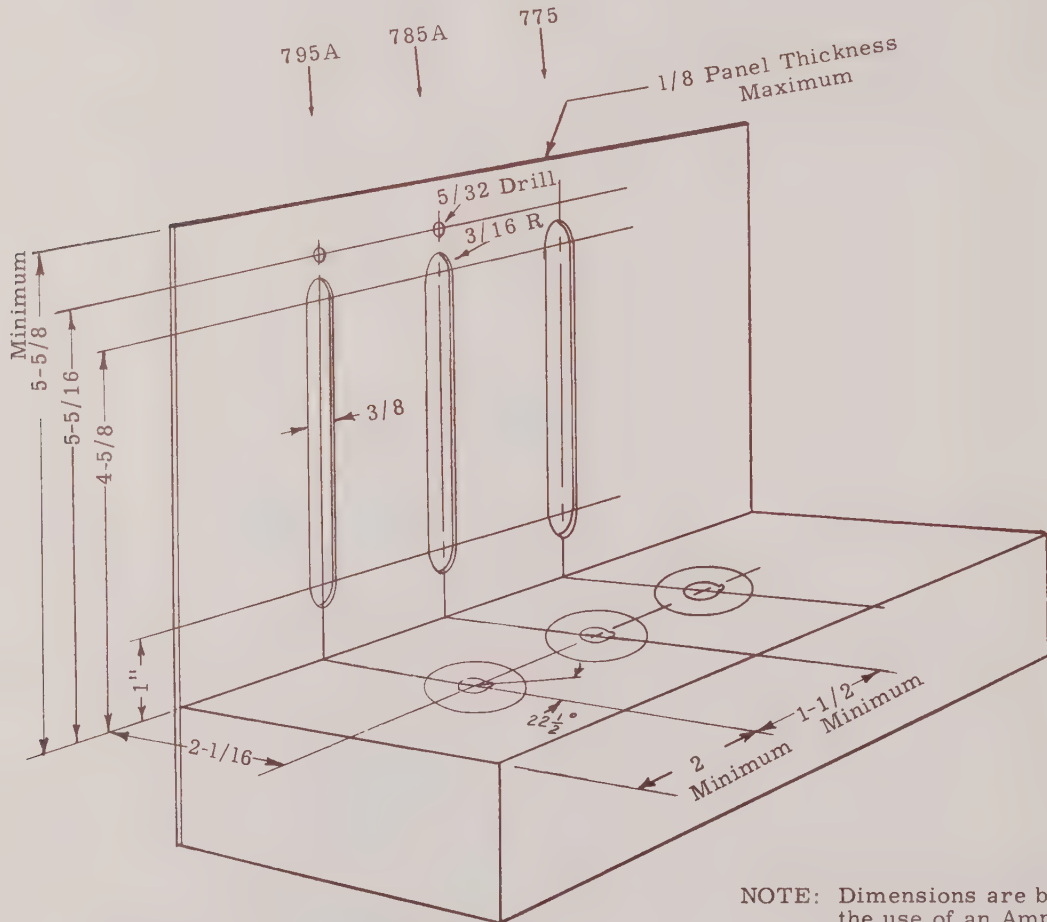


FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785A
OR 795A DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 6 volts peak amplitude is required to trigger the unit. The rise time should be less than 0,025 microseconds, and the duration not more than 0,05 microseconds.

OUTPUT CHARACTERISTICS

The output is a negative pulse as shown in Figure 8 (waveform taken at pin 4 of P101). The pulse is 7v in amplitude, 0.25 microseconds wide, and 0.10 microseconds in rise time. It is suitable for driving a 1 mc DCU (Model 785A). Maximum tolerable load is 100 μ f in series with 1K,

METHOD OF RESETTING TO ZERO

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY-CODED READOUT

The output at pins 2, 6, 9 and 10 of the DCU plug may be used to operate another binary-coded readout or printing device. Refer to the Binary Readout Code on page 5 to learn the relationship between binary digits and the plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 795A DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

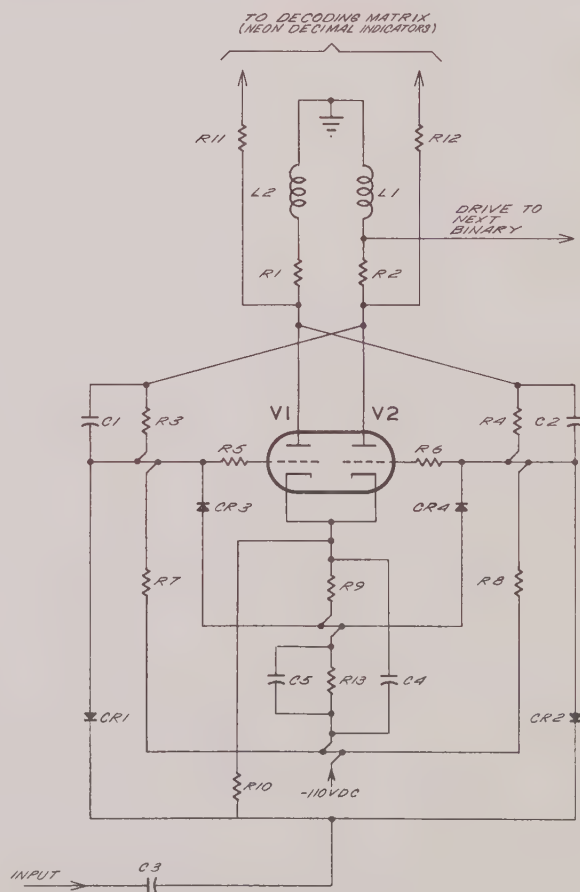


FIGURE 2.
A TYPICAL BINARY STAGE

The circuit is triggered from one state to another by negative pulses applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 30 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 22 volts. CR1 will not conduct since its plate is negative of 22 volts.

However, CR2 will conduct and the negative pulse at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, reinforces the negative pulse there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input pulse causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input pulses applied, making it a scale of two. The output is a negative pulse produced by peaking coil L1 when the right triode conducts and its plate voltage drops. This output, consisting of one negative pulse for every two input pulses, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would

be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 795A three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

At the beginning of a cycle the gate control binary is in the state that holds the gate open. For the first three counts (that is, counts 1 thru 3) the unit operates as a simple binary counter. At count 4 the third binary is triggered for the first time and in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse that triggers the gate control binary back to the "open" state. During counts 7, 8, 9 and 10 the unit again operates as a simple binary chain. At count 10 the third binary produces a negative output pulse that will drive another decimal counting unit.

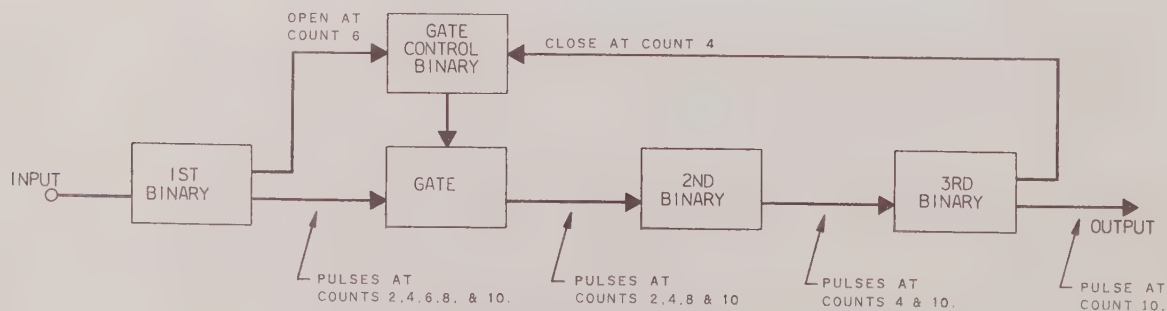


FIGURE 3.
BLOCK DIAGRAM OF MODEL 795A DCU

The operating sequence of the DCU is summarized in Table 1 below which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off. The "4th" binary is the gate control binary.

TABLE 1

Count Display	State of Each Binary Stage			
	4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

Figure 4 shows how plate voltages throughout the unit change as successive counts are received. The output voltage used to drive succeeding binaries is taken from the junction of a plate load resistor and an RF peaking coil rather than from the plate itself. The waveforms at this junction are negative pulses that occur when plate current increases and plate voltage drops.

The negative pulses, coinciding with negative transients in Figure 4, drive succeeding binaries. The gate tube (V105) is driven by negative pulses from the first binary. The gate tube passes the pulse occurring on counts 2, 4, 8 and 10. At count 6, however, the negative pulse from the gate is prevented from reaching the second binary by the action described in the following paragraph.

At count 4, the third binary switches states. The resulting positive transient at plate B is accompanied

by a simultaneous negative transient at plate A. The negative transient, coupled to grid B of the gate control binary, causes this binary to switch to a state in which triode A is conducting. The resulting negative potential at plate A is applied to the grid of triode B in the gate tube. This closes the gate by cutting off triode B, so that the negative pulse generated by the first binary at count 6 cannot reach the second binary. However, this pulse is coupled from the cathode of the gate tube to grid A of the control binary. There, it cuts off triode A, thus returning the control binary to its original stable state and re-opening the gate to pass a pulse to the second binary at count 8.

BINARY CODED ELECTRICAL READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Note that the voltage at pin 6 combines the output of the second binary and the output of triode B of the control binary while the voltage at pin 10 combines the output of the third binary with that of triode A of the control binary. The resultant modified binary code given in Table 2 agrees with that generated by other Beckman instruments. In the table, "0" represents a voltage of -12v or more negative with respect to ground; "1" represents a voltage at ground level or positive with respect to ground.

TABLE 2
BINARY READOUT CODE

Count Display	Pin on DCU Plug			
	10th	9th	6th	2nd
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

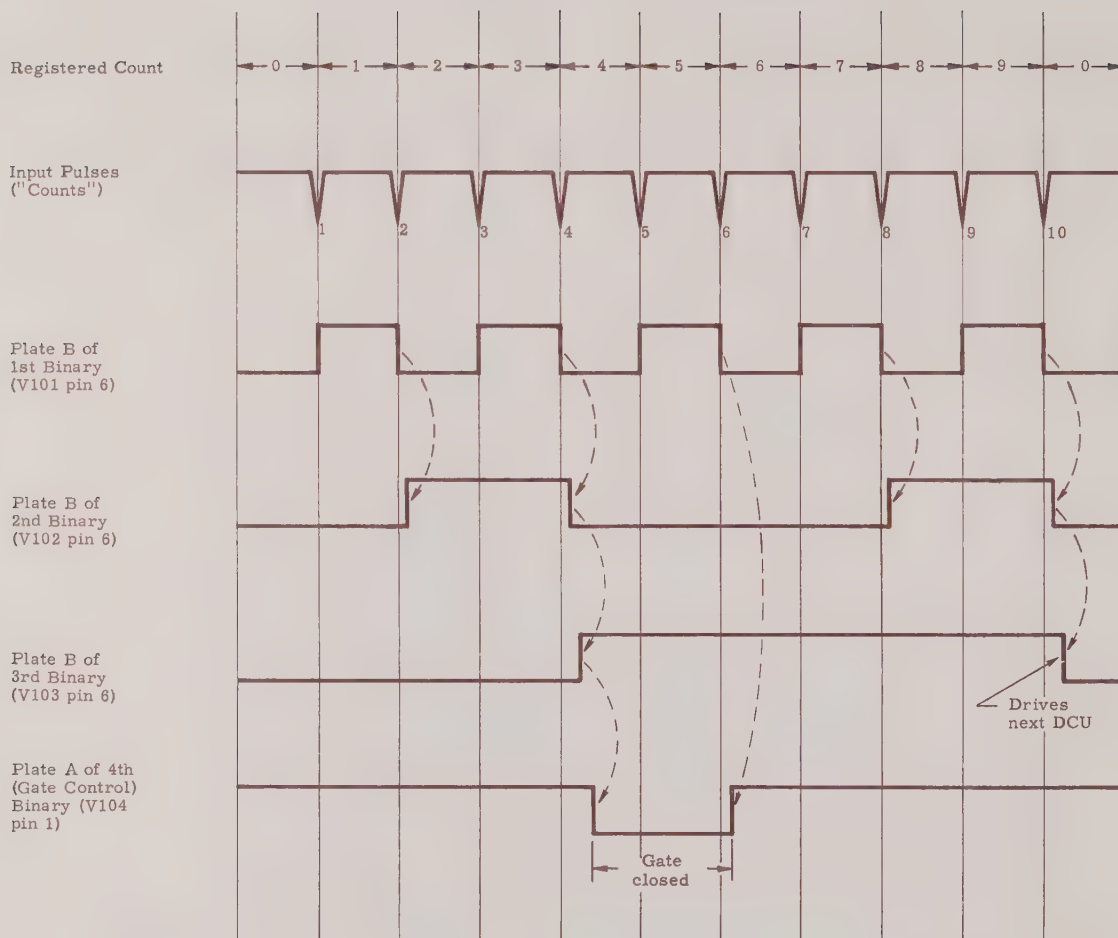


FIGURE 4.
IDEALIZED WAVEFORMS

The negative switching transients trigger succeeding binary stages as indicated by dashed lines. The positive transient at plate B of the 3rd binary is accompanied by a negative transient at plate A that triggers the gate control binary. Notice that the gate, although opened by a pulse from the 1st binary at count 6, does not open soon enough to pass this pulse to the 2nd binary. See figure 8 for actual waveforms.

THE DECODING MATRIX

As the DCU cycles from a registered count of 0 through a registered count of 9, ten discrete combinations of binary states are produced. Any particular combination is represented by eight dc voltage levels, one from each plate of each of the four binaries. These voltages are applied to a decoding matrix consisting of a network of resistors, diodes and neon bulbs. The voltages at the plates of the first binary, V101A and V101B, are amplified by V106A and V106B before application to the matrix. The matrix contains a set of "and" gates, constructed in such a way as to apply breakdown potential across a neon bulb only when the combination of dc voltages representing that bulb number occurs.

Table 3 shows the plate voltages applied to the decoding matrix during each of the ten discrete states of the unit. "H" denotes a "high" voltage; that is, the voltage produced at the plate when the triode is cut off. "L" denotes a "low" voltage; that is, the voltage created when the triode is conducting. The "H" voltage is always positive with respect to the "L" voltage, but whether it is actually a higher voltage with respect to ground depends upon the point where the triode plate circuit is grounded. In some triode circuits the B+ point is grounded, so that all plate voltages are negative with respect to ground, the "H" voltage being less negative than the "L" voltage.

Registered Count		0	1	2	3	4	5	6	7	8	9	
Binary Code	1st binary (V101)	0	1	0	1	0	1	0	1	0	1	
	2nd binary (V102)	0	0	1	1	0	0	0	0	1	1	
	3rd binary (V103)	0	0	0	0	1	1	1	1	1	1	
	4th binary (V104)	0	0	0	0	1	1	0	0	0	0	
To Plate of ↓	Neon Lamp ↓	To Plate of ↓										
V106B	0	V102B	L*	L*	H	H	L	L	L	H	H	
V106A	1	V103B	L*	L*	L	L	H	H	H	H	H	
V106B	2	V102A	H	H	L*	L*	H	H	H	L	L	
V106A	3	V103B	L	L	L*	L*	H	H	H	H	H	
V106B	4											
V106A	5	V104A	H	H	H	H	L*	L*	H	H	H	
V106B	6	V102B	L	L	H	H	L	L	L*	L*	H	H
		V103A	H	H	H	H	L	L	L*	L*	L	L
V106A	7	V104B	L	L	L	L	H	H	L*	L*	L	L
V106B	8	V102A	H	H	L	L	H	H	H	L*	L*	
V106A	9	V103A	H	H	H	H	L	L	L	L*	L*	

TABLE 3
DECODING SCHEME: BINARY STATES TO DECIMAL DIGITS
See "The Decoding Matrix" for explanation.

For a lamp to light, the plate connected to the left-hand terminal (as shown in the table) must be "high" and all plates connected to the right-hand terminal must be "low". The voltages at the left-hand terminals determine whether an even-numbered or an odd-numbered lamp will light. When the registered count is an even number, the plate of V106B is high and the plate of V106A is low; when the registered count is odd these voltages are reversed. The voltages at the right-hand terminals determine which of the five odd-even pairs (0 & 1, 2 & 3, 4 & 5, 6 & 7 or 8 & 9) will have an opportunity to light. Notice that for any given registered count, only one pair

will be connected to plates, all of which are low. These points are marked by an asterisk in the table.

To take an example, suppose the registered count is 3. Searching the column under "3" we find that two low plates (V102A & V103B) are connected to neon pair 2 & 3. This provides the necessary "low" voltage at the right-hand terminals of the bulbs. Since 3 is an odd number, the plate of V106A is high and that of V106B, low. Therefore, neon 3, connected between high and low voltages, lights, whereas neon 2 remains extinguished.

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. These pictures were taken using an input frequency of 10

megacycles. The waveshapes differ slightly and peak-to-peak voltages are smaller than at lower frequencies. Voltage and resistance measurements at tube pins are given in table 6.

Locating the source of erratic operation is sometimes difficult because a feedback loop from the 3rd binary, through the 4th binary to the 2nd binary, makes all these stages interdependent. A failure in one stage will cause all to malfunction. To facilitate troubleshooting, the feedback loop can be broken by removing the 4th binary tube (V104). The DCU then becomes a simple chain of three binaries, V101, V102 and V103. These binaries form a scale-of-eight, so that if all three are operating correctly the unit will cycle through eight rather than ten discrete states. At slow speeds this produces the indicating sequence 0-1-2-3-6-7-8-9. At higher speeds output waveforms will appear as square waves, each binary producing waves at half the frequency and twice the pulse width of the preceding binary. Since there is no interaction between stages, trouble can be located by straightforward signal tracing.

Trouble in the binary stages (V101 thru V104) can be distinguished from troubles in the decoding circuitry by comparing binary output waveforms with the lighting sequence. If waveforms are correct but lighting sequence is erroneous, trouble lies in the decoding circuitry. It will be found that most failures are caused by faulty tubes or crystal diodes.

TABLE 4

TROUBLESHOOTING CHART

NOTE: Reset unit before troubleshooting.

<u>Symptom</u>	<u>Cause</u>	<u>Symptom</u>	<u>Cause</u>
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First binary stage inoperative	2. Skips 4 and 5 3. Skips 6 and 7	(a) 4th binary stage (V104) not being driven by the 3rd (V103) (a) Gate tube (V105) not being driven by V104
Unit counts spuriously without input signal	(a) Stray input signal (b) Pulses received through power supply	Repeats a pattern of numbers 1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd binary stage (V102) not being driven (b) Defective gate tube (V105)
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much	2. Four stable states per cycle (0-1-2-3 or 6-7-8-9) 3. Counts up to 5, then alternates between 4-5	(a) 3rd binary stage (V103) not being driven (a) 4th binary stage (V104) not being driven by the 1st (V105)
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component	Two or more lamps light simultaneously	Defective amplifier stage (V106)
Unit counts in wrong sequence 1. Skips every other number	(a) First binary stage (V101) defective (b) Input circuit supplies double pulses	Skips one number on indicator but binary-coded output count is correct	Defective neon lamp

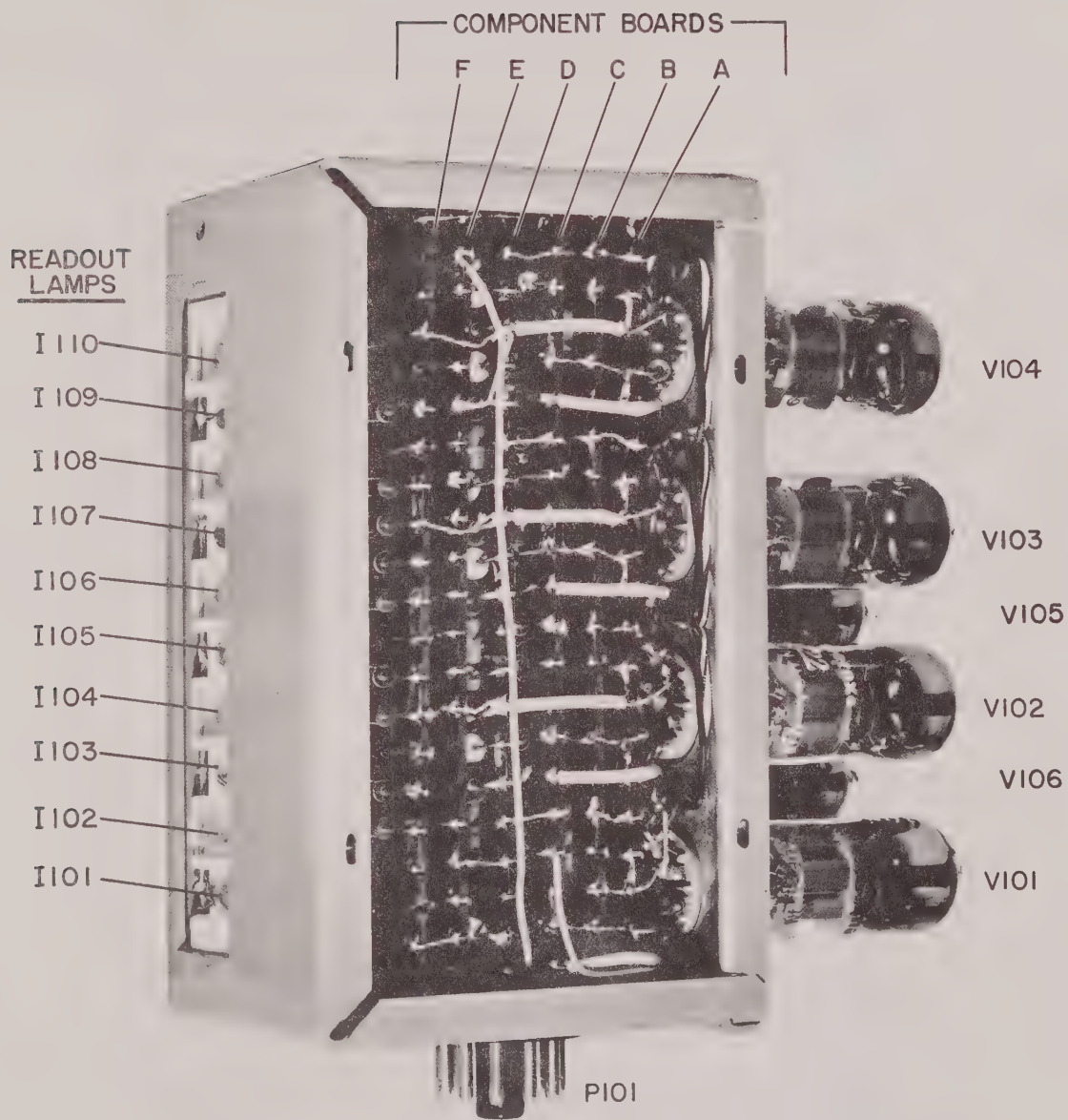
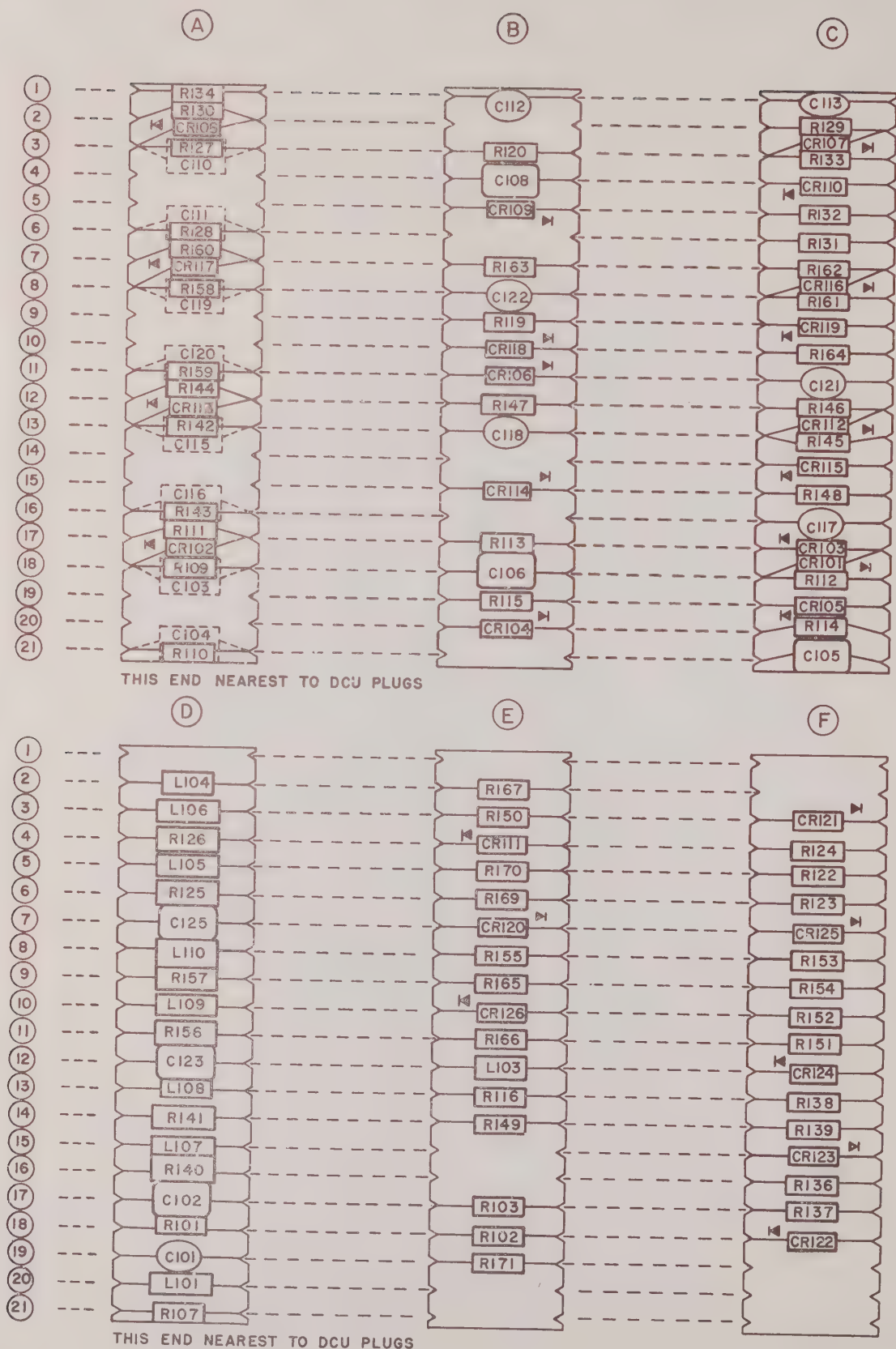


FIGURE 5
MODEL 795A DCU WITH NUMBER MASK REMOVED



60-B1

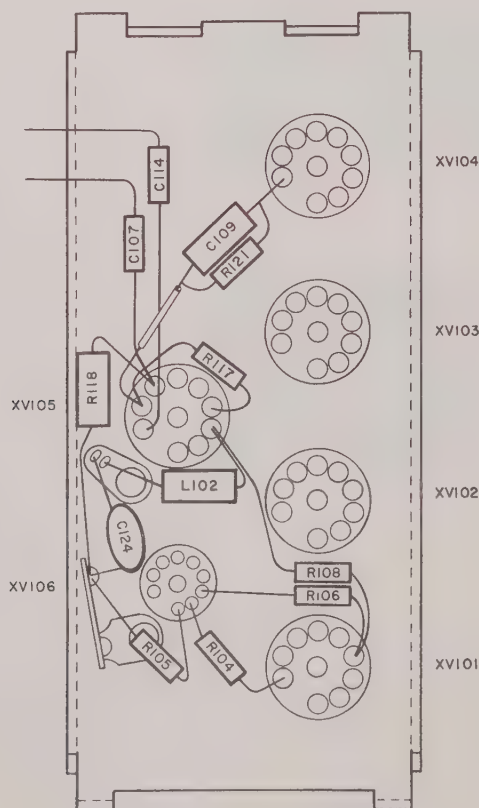
FIGURE 6
COMPONENT BOARD LAYOUT. COMPONENTS SHOWN DASHED ARE ON REVERSE SIDE OF BOARD

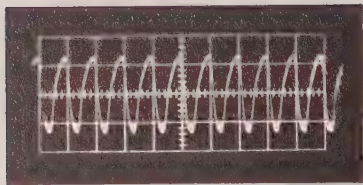
TABLE 5 PARTS LOCATION GUIDE*

Reference Number	Position (Fig. 6)	Reference Number	Position (Fig. 6)	Reference Number	Position (Fig. 6)
C101	D 19	CR120	E 7	R130	A 2
C102	D 17	CR121	F 3	R131	C 6
C103	A 19	CR122	F 18	R132	C 5
C104	A 20	CR123	F 15	R133	C 3
C105	C 21	CR124	F 12	R134	A 1
C106	B 18	CR125	F 7	R136	F 16
C108	B 4	CR126	E 10	R137	F 17
C110	A 6			R138	F 13
C111	B 1	L101	D 20	R139	F 14
C112	C 1	L103	E 12	R140	D 16
C113	A 14	L104	D 2	R141	D 14
C115	A 15	L105	D 5	R142	A 13
C116	C 16	L106	D 3	R143	A 16
C117	B 13	L107	D 15	R144	A 12
C118	A 9	L108	D 13	R145	C 13
C119	A 10	L109	D 10	R146	C 12
C120	C 11	L110	D 8	R147	B 12
C121	B 8			R148	C 15
C122	D 12			R149	E 14
C123	D 7			R150	E 3
C125				R151	F 11
		R101	D 18	R152	F 10
		R102	E 18	R153	F 8
		R103	E 17	R154	F 9
		R107	D 21	R155	E 8
CR101	C 17	R109	A 18	R156	D 11
CR102	A 17	R110	A 21	R157	D 9
CR103	C 17	R111	A 17	R158	A 8
CR104	B 20	R112	C 18	R159	A 11
CR105	C 19	R113	B 17	R160	A 7
CR106	B 11	R114	C 20	R161	C 8
CR107	C 3	R115	B 19	R162	C 7
CR108	A 3	R116	E 13	R163	B 7
CR109	B 5	R119	B 9	R164	C 10
CR110	C 4	R120	B 3	R165	E 9
CR111	E 4	R122	F 5	R166	E 11
CR112	C 13	R123	F 6	R167	E 2
CR113	A 12	R124	F 4	R169	E 6
CR114	B 15	R125	D 6	R170	E 5
CR115	C 14	R126	D 4	R171	E 19
CR116	C 8	R127	A 3		
CR117	A 7	R128	A 6		
CR118	B 10	R129	C 2		
CR119	C 9				

*Parts not listed in this table can be found on Figures 5 and 7.

FIGURE 7
THIS DIAGRAM GIVES THE LOCATION
OF CHASSIS-MOUNTED COMPONENTS

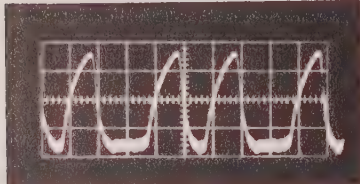




FIRST BINARY, PLATE B

Test Point: V101, pin 6

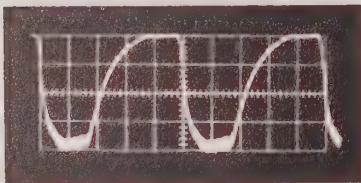
Vert. Scale: 10v/div



SECOND BINARY, PLATE B

Test Point: V102, pin 6

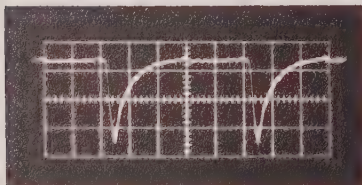
Vert. Scale: 10v/div



THIRD BINARY, PLATE B

Test Point: V103, pin 6

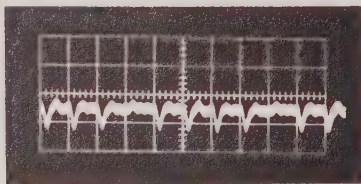
Vert. Scale: 10v/div



FOURTH (GATE CONTROL) BINARY, PLATE A

Test Point: V104, pin 1

Vert. Scale: 10v/div

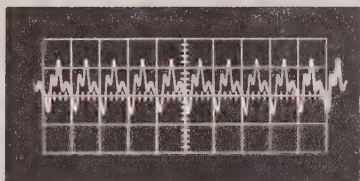


GATED PULSES TO SECOND BINARY

Test Point: V105, pin 1

Vert. Scale: 5v/div

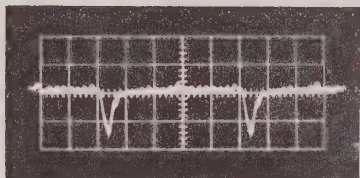
FIGURE 8a
TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 10 MC.
EACH PICTURE SHOWS TWO COMPLETE DCU CYCLES*
STARTING FROM A REGISTERED COUNT OF ZERO.
TIME SCALE IS $0.2\mu\text{S}/\text{DIV}$



SIGNAL FROM GATE TO FOURTH
(GATE CONTROL) BINARY

Test Point: V105, pins 3 & 8

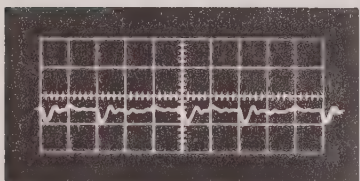
Vert. Scale: 5v/div



GATE OPEN/CLOSE SIGNAL

Test Point: V105, pin 2

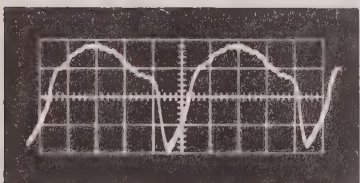
Vert. Scale: 5v/div



DRIVE PULSES TO THIRD BINARY

Test Point: Junction of L108 & R141

Vert. Scale: 5v/div



OUTPUT SIGNAL

Test Point: P101, pin 4

Vert. Scale: 2v/div

FIGURE 8b

TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 10 MC.

EACH PICTURE SHOWS TWO COMPLETE DCU CYCLES

STARTING FROM A REGISTERED COUNT OF ZERO.

TIME SCALE IS 0.2 μ S/DIV

VOLTAGES

TABLE 6a

Note: Voltages measured to ground at registered count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 120 volts. B- voltage is -110 volts. Voltages may vary $\pm 10\%$ due to component tolerances and tube variations.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	-3.5	-90	-85	Fil	Fil	-35	-85	-85	-85
V102	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V103	-9	-90	-85	Fil	Fil	-54	-85	-85	-85
V104	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V105	+105	-4.5	+2	Fil	Fil	+105	0	+2	0
V106	-15	+25	Fil	Fil	-35	-20	-20		

RESISTANCES

TABLE 6b

Note: Resistances are measured to chassis ground with the DCU removed from its socket. Where path to ground goes through a diode, resistance reading depends upon polarity and magnitude of voltage applied by ohmmeter. These readings taken with RCA Volt-ohmyst Senior with negative terminal to chassis ground. Applied voltage was approximately 1.5v.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	2.1K	9.6K	7.5K	∞	∞	2.1K	9.6K	7.5K	7.5K
V102	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V103	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V104	3.2K	10.5K	8K	∞	∞	3.9K	10.5K	8K	8K
V105	100K	3.1K	20K	∞	∞	100K	0	20K	
V106	300K	300K	∞	∞	110K	110K	135K		

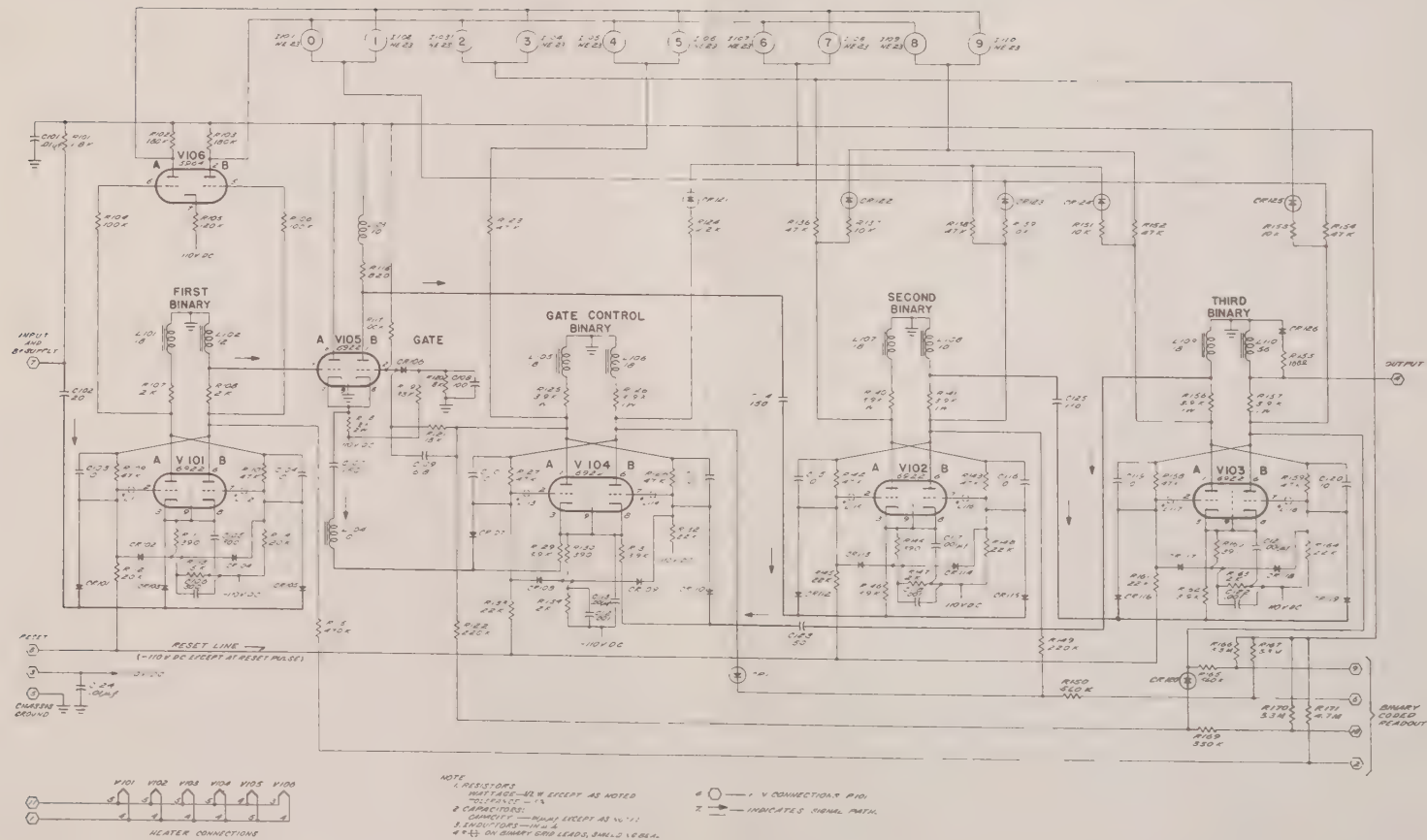
PARTS LIST

This list includes all electrical parts except resistors. All resistors are Allen-Bradley fixed composition types of the value, power rating and tolerance noted on the schematic diagram.

Detail No.	Beckman Stock No.	Description	Manufacturer & Manufacturer's No.
C101	2-4388	Cap., .01 μ fd, disc, axial leads	Sprague 59929
C102	2-1939	Cap., 20 μ fd, 500v dc, silvered mica	Sangamo RR 1420
C103	2-2082	Cap., 10 μ fd, 500v dc, silvered mica	Sangamo RR 1410
C104		Same as C103	
C105	2-2608	Cap., 300 μ fd, 300v dc, silvered mica	Sangamo RR 1330
C106		Same as C105	
C107	2-5491	Cap., 150 μ fd, 500v dc, silvered mica	Sangamo RR 1315
C108	2-2136	Cap., 100 μ fd, 500v dc, silvered mica	Sangamo RR 1310
C109	2-3508	Cap., 6.8 μ fd, 600v dc, ceramic tubular	Erie GP1K
C110 & C111		Same as C103	
C112	2-5793	Cap., .001 μ fd, disc	Centralab DD102
C113		Same as C112	
C114		Same as C107	
C115 & C116		Same as C103	
C117 & C118		Same as C112	
C119 & C120		Same as C103	
C121 & C122		Same as C112	
C123		Same as C107	
C124		Same as C101	
C125		Same as C107	
CR101	409096	Diode, 1N198, point contact type	Hughes
CR102 thru CR110		Same as CR101	
CR111	404593	Diode,	B/B
CR112 thru CR119		Same as CR101	
CR120 thru CR125		Same as CR111	
CR126		Same as CR101	
I101	21-6180	Lamp, NE23	GE
I102 thru I110		Same as I101	
L101	3-7330	Choke, 18 μ h, molded	Nat. Coil QA-18-I
L102	3-7512	Choke, 12 μ h, molded	Nat. Coil NA-12-I
L103	3-7332	Choke, 10 μ h, molded	Nat. Coil NA-10-I
L104		Same as L103	
L105 thru L107		Same as L101	
L108		Same as L103	
L109		Same as L101	
L110	3-7333	Choke, 56 μ h, molded	Nat. Coil RA-56-I
L111 thru L118	3-7251	Shielding Bead	Ferroxcube Corp. 255T118A205

<u>Detail No.</u>	<u>Beckman Stock No.</u>	<u>Description</u>	<u>Manufacturer & Manufacturer's No.</u>
P101	17-1719	Connector, 11-pin, octal style	Amphenol 86-CP11
V101	5-4764	Tube, 6922	Amperex
V102 thru V105		Same as V101	
V106	5-2494	Tube, 5964	RCA
XV101	4-3317	Socket, 9-pin	Cinch 16111
XV102 thru XV105		Same as XV101	
XV106	4-3316	Socket, 7 pin	Cinch 14700

MODEL 795A DCU SCHEMATIC DIAGRAM



NOTE
1. RESISTORS
VALUES - 1% EXCEPT AS NOTED
2. CAPACITORS
VALUES - 1% EXCEPT AS NOTED
3. DIODES
VALUES - 1% EXCEPT AS NOTED
4. 1% ON BINARY GND LEADS, 5% ON 100%
5. DIODES ARE TO BECKMAN SPEC., BVR AT 50V-100V, ALL OTHER DIODES - 1N130.

<u>Detail</u> <u>No.</u>	<u>Beckman</u> <u>Stock</u> <u>No.</u>	<u>Description</u>	<u>Manufacturer &</u> <u>Manufacturer's No.</u>
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August 1963

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